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The terrestrial slugs of KwaZulu-Natal: diversity, biogeography and conservation (Mollusca: Pulmonata)

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ABSTRACT

The terrestrial slug fauna of KwaZulu-Natal is reviewed and matters relating to biogeography, conservation and economic importance discussed. Eighteen species are recorded from the province, double the number since the last similar review by Collinge in 1910. Eight species are alien introductions. The indigenous fauna is either endemic or of tropical/subtropical affinity; at the species level there is no overlap with taxa characteristic of the Cape. The endemic family Chlamydephoridae and the veronicellid *Laevicaulis haroldi* are considered to be conservation priorities. New records of *Urocyclus kirkii* confirm its occurrence in KwaZulu-Natal. Keys to families, genera and species are provided, together with illustrations, photographs, descriptions, locality and habitat data, and distribution maps.

INTRODUCTION

The subject of this paper is essentially the same as that of a paper by Walter Collinge, published in this same journal in 1910. In the intervening 87 years there has been no subsequent collective analysis of the slug fauna of the province, though this is not to say that the slugs of the region have not been studied during this period. Most subsequent studies, however, have examined these animals from a taxonomic rather than a geographic perspective, and have thus been concerned more with revisionary studies of specific groups in broader geographical areas (southern Africa or Africa). Examples of such include the studies of Watson (1915) on the Aperidae (now Chlamydephoridae), Forcart (1953) on the Veronicellidae and Van Goethem (1977) on the Urocyclinae. Aside from these, there have been isolated records of slug species in reviews of the terrestrial molluscs of particular areas (e.g. Bruggen 1966 1969, Bruggen & Appleton 1977), in discussions of introduced molluscs (Bruggen 1964, Altena 1966), in works dealing with elements of the molluscan fauna of the southern African subregion as a whole (Simroth 1907, Connolly 1939, Forcart 1963) and in biogeographical analyses (Bruggen 1978 1986).

Most of these publications, however, are of limited use to anyone save the specialist. Few give characters that can be and were used in species discrimination. The result is that in the absence of local specialists our knowledge of the province's slug fauna has progressed at a pace akin to that of their shell bearing relatives. Indeed, in recent years it has come to a virtual halt. Whilst the taxonomy may appear to be relatively well established in some groups, it is clearly not so in others. In some cases conclusions have had to be drawn using a very limited amount of material,

[1] All photographs in this paper were taken by the author.

sometimes even using alcohol preserved specimens only. Already a number of such conclusions have had to be reassessed in the light of evidence obtained from additional material [e.g. Forcart's 1967 reinterpretation of his 1953 observations on *Laevicaulis saxicolus* (Cockerell in Cockerell & Collinge, 1893)]. It is clear also that the known distributional and altitudinal ranges of many of the species are far from complete and reflect only the sites at which earlier workers collected.

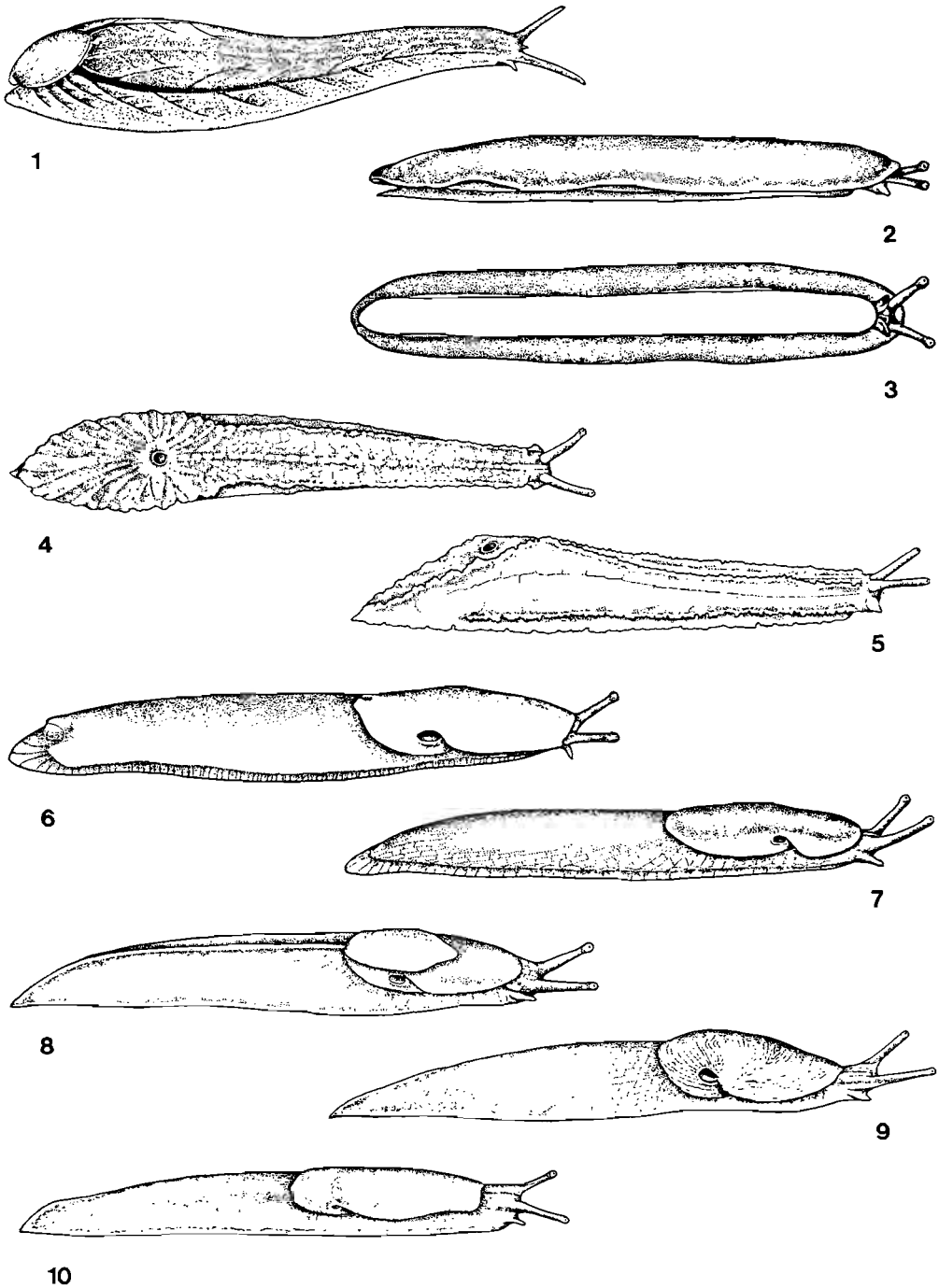
Although the value of these earlier contributions is considerable, our knowledge of the slug fauna of KwaZulu-Natal is nevertheless woefully inadequate. The lack of any kind of up-to-date review of the province's slug fauna is a major stumbling block to furthering our understanding of the group in a local context. The limited amount of information currently available is scattered through the malacological literature and is often difficult for the non-specialist to obtain. The result of this is that scientists, other than those specifically interested in slugs from a systematic perspective (and there are none currently studying the local ones), tend to omit the group from consideration in the course of their studies. This is understandable – they simply have no tool to assist them to do otherwise.

This contribution is thus an attempt to remedy this situation. It is not the product of extensive research combined with a thorough field-work programme, and does not offer major new findings relating to the provincial slug fauna, nor new insights into the systematics of the group. It is a synthesis based on existing information, supplemented with additional locality data and field observations. It is aimed at the broader community of biologists and conservationists, rather than the mollusc specialist. Hopefully it will function as an easy-to-use tool enabling slugs to be considered when, for example, regional biodiversity is assessed, and ecologists study changes in faunal composition related to altered land use practices. With the relatively small number of taxa involved and the interesting mix of indigenous and exotic species, regional slugs may prove to be valuable indicator species. Hopefully also, by highlighting our poor knowledge of the group, I will stimulate others to look more closely at this interesting group of animals.

Finally, in producing this guide, I am confident that, as further field-work reveals additional indigenous taxa and unrecorded introductions, it will soon prove not to be the comprehensive guide that I intend it to be.

COLLECTING SLUGS

There are no special techniques for collecting slugs. The great majority of species are primarily nocturnal and spend the day hidden from view in shady places, usually under logs, stones and fallen bark, within the leaf-litter layer of forests and woodlands or in compost heaps. The only exception to this amongst local species is *Elisolimax flavescens*, which can be found resting in exposed positions on leaves of under-storey plants, on tree trunks and even on the walls of buildings, though still usually in the shade. The remaining species are best collected using the simple techniques used for sampling cryptic invertebrate biota in general, such as sifting through leaf-litter and turning over stones and fallen logs. Some can also be found by torchlight at night, when they emerge to forage for food, particularly when there has been rain or a heavy dew. The most difficult species to collect are members of the



Figs 1–10. Drawings of slugs representative of the families occurring in South Africa. **1**. Testacellidae. **2–3**. Veronicellidae. **4–5**. Chlamydephoridae. **6**. Urocyclidae (Urocyclinae). **7**. Arionidae. **8**. Milacidae. **9**. Limacidae. **10**. Agriolimacidae.

Chlamydephoridae which seem to be primarily subterranean. Although some, such as *Chlamydephorus sexangulus* and *C. gibbonsi* have been found in loose leaf-litter, most of the chlamydephorid specimens available have been collected under large stones and fallen logs or deep within rotting tree stumps. Heavy rains which cause water-logging of the soil may also bring such subterranean species to the surface, sometimes in quite surprising habitats (cf. *C. gibbonsi*).

Slugs should be preserved in 70 % alcohol (ethanol) having first been relaxed by drowning. This is achieved by immersing them in a jar filled with water and screwing on the lid, at the same time excluding as much air as possible. After about 12 hrs the specimens will be fully extended and the water may be replaced with alcohol without the specimens contracting. Since the water content of slugs is high, the alcohol should be changed after one to two days and any coagulated mucus should be gently scraped off the specimens. There will inevitably be some shrinkage and loss of pigment as the alcohol fixes the tissues.

CHECK-LIST OF SPECIES OCCURRING IN KWAZULU-NATAL

Indigenous species (10)

Veronicellidae
Laevicaulis alte (Férussac, 1821)
Laevicaulis haroldi Dundee, 1980
Laevicaulis natalensis natalensis (Krauss, 1848)
Chlamydephoridae
Chlamydephorus burnupi (Smith, 1892)
Chlamydephorus dimidius (Watson, 1915)
Chlamydephorus gibbonsi Binney, 1879
Chlamydephorus sexangulus (Watson, 1915)
Urocyclidae
Atoxonoides meridionalis (Forcart, 1967)
Elisolimax flavescens (Keferstein, 1866)
Urocyclus kirkii Gray, 1864 (confirmed record)

Introduced species (8)

Arionidae
Arion intermedius Normand, 1852
Milacidae
Milax gagates (Draparnaud, 1801)
Limacidae
Lehmannia nyctelia (Bourguignat, 1861)
Lehmannia valentiana (Férussac, 1821)
Limax flavus Linnaeus, 1758
Limax maximus Linnaeus, 1758
Agriolimacidae
Deroceras reticulatum (Müller, 1774)
Deroceras laeve (Müller, 1774)

KEY TO FAMILIES OF SLUGS IN SOUTH AFRICA[2]

1 External shell absent 2
– Posterior region with small, limpet-like, external shell (Fig. 1)..... **Testacellidae**

2 Body either entirely covered by a leathery mantle or mantle completely absent... 3
– Mantle present as a saddle-shaped shield in mid to anterior region..... 4

3 Mantle covering entire body and appearing as a smooth, somewhat leathery shield (the notum); no pneumostome on dorsal surface (Figs 2, 3). ..... **Veronicellidae** (p 201)
– Mantle absent; dorsal surface distinctly grooved and with a pneumostome situated in the mid-line, near the posterior end (Figs 4, 5). ..... **Chlamydephoridae** (p 207)

4 Posterior of body with small appendage above tip of tail; posterior of mantle shield with a small pore (not pneumostome) (Fig. 6) ..... **Urocyclidae** (p 214)
– No appendage above tail and mantle shield without posterior pore 5

5 Pneumostome anterior to mid-point of mantle shield (Fig. 7); sole of foot not longitudinally tripartite..... **Arionidae** (p 218)
– Pneumostome posterior to mid-point of mantle shield (Figs 8, 9); sole of foot longitudinally tripartite..... 6

6 Posterior keel extending from tip of tail to mantle shield; mantle with characteristic horseshoe-shaped groove (Fig. 8); central division of sole with herring-bone pattern ..... **Milacidae** (p 220)
– Posterior keel not reaching mantle shield; mantle with pattern of concentric grooves resembling a finger-print (Figs 9, 10); central division of sole lacking herring-bone pattern 7

7 Mantle finger-print centred about mid-line; posterior of foot gently sloping (Fig. 9); generally > 40 mm in length ..... **Limacidae** (p 221)
– Mantle finger-print centred to right of mid-line; posterior of foot steeply sloping (Fig. 10); generally < 40 mm in length ..... **Agriolimacidae** (p 226)

INDIGENOUS SPECIES

Family Veronicellidae

Genus *Laevicaulis* Simroth, 1913

Type species: *Vaginula comorensis* Fischer, 1883.

Distribution: Almost circumtropical; introduced in many areas but indigenous in Africa. Distribution in Africa limited to the moister central latitudinal belt (particularly the great lakes region) and the eastern coastal lowlands, from southern Somalia to the Eastern Cape.

Moderately large, herbivorous slugs in which the body is entirely covered by a thick, leathery, more or less smooth, uniformly textured mantle (notum) that is

[2] The key treats all South African slug families, since it is possible that all may eventually prove to occur in KwaZulu-Natal. At present only the family Testacellidae is not known from the province. In South Africa this family is represented solely by the European *Testacella maugei* Férussac, 1819 (introduced prior to 1893), which has to date been recorded only from the extreme south-western Cape.

Figs 11–16. Photographs of KwaZulu-Natal slugs. **11**. *Laevicaulis natalensis natalensis* (Krauss, 1848); Oak Park, Pietermaritzburg. **12**. *Laevicaulis alte* (Férussac, 1821); Pelham, Pietermaritzburg. **13**. *Laevicaulis haroldi* Dundee, 1980; Hluhluwe Game Reserve, Zululand. **14**. *Elisolimax flavescens* (Keferstein, 1866) – yellow colour variety; Pietermaritzburg. **15**. *Elisolimax flavescens* (Keferstein, 1866) – grey colour variety; Shelly Beach. **16**. *Limax flavus* Linnaeus, 1758; Winterskloof, Pietermaritzburg.

somewhat dry to the touch. When crawling the head remains largely hidden under the mantle, with only the upper tentacles projecting much beyond the slightly raised front margin. There is no mantle cavity or pneumostome and no internal shell.

Laevicaulis is primarily an afrotropical genus, with *L. alte* the only extralimital species. In southern Africa, the species are indigenous only in the warmer eastern regions where rainfall is in excess of 400 mm per annum, but some are nonetheless capable of withstanding harsher, drier conditions (including savannah) than most other slug species. The species-level taxonomy of the genus is not well established and the taxa are difficult to separate without dissection, since variation in colour is evidently considerable. Three species are recognised in South Africa and all are indigenous in KwaZulu-Natal.

Key to species of *Laevicaulis* in KwaZulu-Natal

1 Notum cream to dark brown, usually with distinct transverse bands and bearing transverse wrinkles (Fig. 13); long and slender when extended ..... **haroldi**
– Notum never with transverse bands of colour and not wrinkled; remaining relatively broad even when extended 2

2 Penial verge with a distinct bulbous swelling at or near its tip (Fig. 18); pale brown mottled with darker blotches to uniformly dark charcoal grey, lacking a thin, pale brown stripe along dorsal mid-line ..... **natalensis natalensis**
– Penial verge tapering evenly at its end and bearing a ring-like swelling near its base (Fig 20); uniformly dark charcoal grey with a thin, pale brown stripe along dorsal mid-line ..... **alte**

Separation of *Laevicaulis natalensis natalensis* and *L. alte*:

Reliable separation of these taxa requires dissection and examination of the penial verge, but is not difficult. This structure is best examined by making a longitudinal incision through the thick leathery mantle just above and behind the right optic tentacle. In mature individuals the penial complex appears as a whitish apparatus lying on the right of the buccal mass and comprises the intromittent penial verge (in a sheath), and the penial stimulator and gland. The latter is easily recognised by its elongate tubules. The cylindrical penis sheath, usually lying to the right of the penial gland, must be cut open to expose the verge. In *L. natalensis natalensis* the verge has a distinct bulbous swelling at or near its tip (Fig. 18); in *L. alte*, the verge is somewhat longer, tapers evenly at the end and has a collar-like swelling near its base (Fig. 20). Although there is some variation in the size and shape of the apical swelling in *L. natalensis natalensis* (Fig. 19), the penis is rarely (if ever) bent or folded within its sheath. In contrast, that of *L. alte* is never apically swollen and, being longer, is frequently folded or partially looped inside the sheath.

Although dissection is necessary to confirm identity, all specimens of *L. alte* that I have dissected have been charcoal-grey (not brown) with a narrow, pale brown, mid-dorsal line. In contrast, specimens confirmed to be *L. natalensis natalenis* by dissection, have never exhibited this coloration. Even when charcoal grey, they lack a pale mid-dorsal line.

Note regarding diseased specimens:

Unusual looking specimens of *Laevicaulis* slugs having a wrinkled, warty

appearance and whitish mottling (Fig. 17) are occasionally encountered. These are thought to be diseased individuals. Although the disease may well affect all *Laevicaulis* species, dissection of the few specimens available reveals that the penis is relatively short with a terminal swelling and thus they are almost certainly individuals of *L. natalensis natalensis*.

Fig. 17. *Laevicaulis natalensis natalensis* (Krauss, 1848), diseased specimen; Pietermaritzburg.

The nature of the infection (if indeed it is a disease) has not been accurately established, but Mead (1979) reported similar symptoms, thought to be caused by *Aeromonas* bacteria, in the snail *Achatina fulica*. Diseased slugs kept in captivity at the Natal Museum have survived for a year or more, although, similarly diseased specimens of *L. alte* in India were reported to die within a few weeks after showing signs of infection (Raut & Mandal 1986). A fatal blistering disease has also been reported in *Veronicella ameghini* Gambetta, 1923 (de Gravelle in Mead 1979). Attempts to infect healthy slugs by scratching the skin and smearing them with mucus from infected specimens proved unsuccessful. In *Achatina* it seems likely that the pathogen is spread on contaminated food (Mead 1979). In view of the potential for biological control the apparent disease merits further study.

Laevicaulis natalensis natalensis (Krauss, 1848)

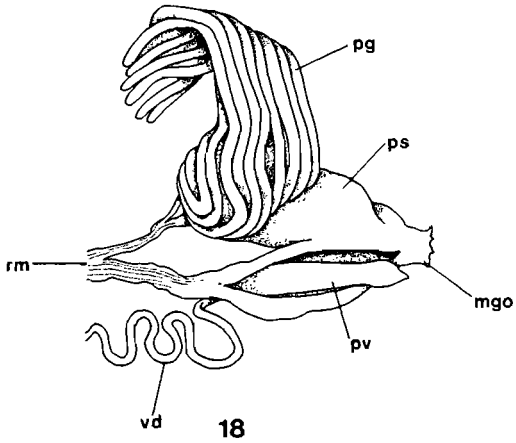
Figs 11, 17–19; Map 2

Vaginulus natalensis (von Rapp) Krauss, 1848: 72. Type loc.: *in terra natalensi*.
Veronicella saxicola Cockerell in Cockerell & Collinge, 1893: 194, 216; Collinge, 1910: 171. Type loc.: Port Elizabeth.
Veronicella natalensis; Collinge, 1910: 170.
Laevicaulis natalensis natalensis; Forcart, 1953: 68, figs and map: *idem*, 1967: 512 (further references); Bruggen, 1966: 390; *idem*, 1968: 50; Bruggen & Appleton, 1977: 38.

General description: Yellowish brown to brown, often with irregular dark greyish mottling; medio-dorsal region frequently lacking mottling, but apparently never with a narrow pale mid-dorsal line (cf. *L. alte*); occasionally entirely charcoal grey; skin of

mantle finely granular if examined closely; upper tentacles greyish brown, lower ones paler; underside of notum (the hyponotum) and sole usually pale yellowish white. Extended length up to 110 mm, perhaps more. Not reliably distinguished from *L. alte* without dissection (see above).

Distribution (Map 2): From Zimbabwe and Mozambique south to the south-eastern Cape (Port Elizabeth); from sea level to about 1800 m (Zimbabwe); in KwaZulu-Natal it has not been recorded further from the coast than Pietermaritzburg (900 m), and Vryheid (1200 m).



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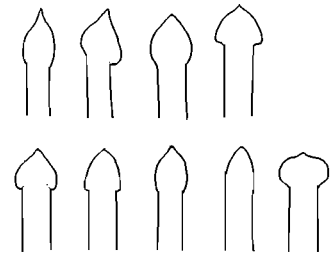

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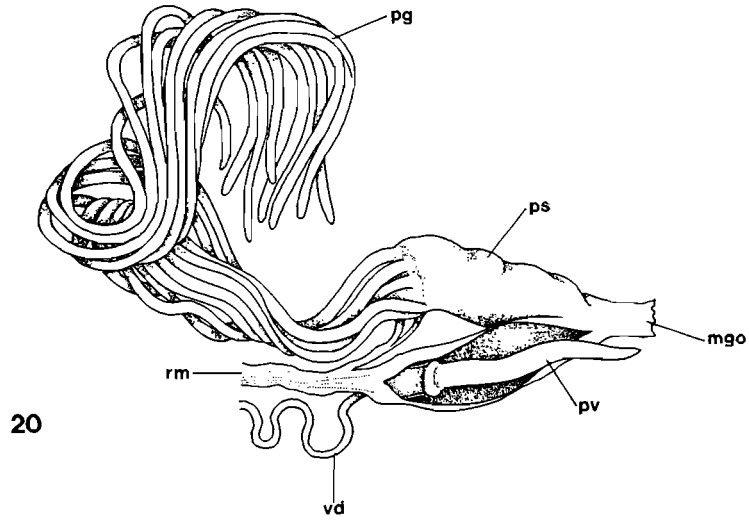

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Figs 18–20. *Laevicaulis natalensis natalensis* (Krauss, 1848) and *L. alte* (Férussac, 1821) – comparison of male genitalia. **18**. *L. n. natalensis* penis sheath cut open to reveal penial verge. **19**. *L. n. natalensis*, variation in shape of tip of penial verge. **20**. *L. alte*, penis sheath cut open to reveal penial verge. [mgo = male genital opening; pg = penial gland with elongate tubules; ps = penial stimulator; pv = penial verge; rm = retractor muscles; vd = vas deferens.]

Figs 21–26. Photographs of KwaZulu-Natal slugs. **21**. *Chlamydephorus burnupi* (Smith, 1892); Ngele Forest, Kokstad. **22**. *Chlamydephorus dimidius* (Watson, 1915); Pigeon Valley Park, Durban. **23**. *Chlamydephorus sexangulus* (Watson, 1915); Mtamvuna Gorge. **24**. *Chlamydephorus gibbonsi* Binney, 1879, paler forest form; Ngome Forest, northern Zululand. **25**. *Chlamydephorus gibbonsi* Binney, 1879, dark thornveld form; Ashburton, Pietermaritzburg. **26**. *Chlamydephorus gibbonsi* Binney, 1879, defensive posture adopted when disturbed; Chase Valley, Pietermaritzburg.

Habitat: Common in a wide range of habitats including mist-belt *Podocarpus* forest, sand forest, suburban gardens, but also able to survive in hotter, drier areas including thornveld and mopane-veld (Bruggen 1966).

Locality data – KwaZulu-Natal: Forcart (1967) recorded this species from numerous localities in the former Natal and Zululand, and personal observations confirm its widespread occurrence in the lower-lying, eastern regions of the province.

Additional South African localities: Port Elizabeth, Port Alfred, East London and the Kruger National Park.

Remarks: *Laeviculis saxicolus* (Cockerell in Cockerell & Collinge, 1893), also recorded from KwaZulu-Natal, is no longer thought to be distinct from this species (Forcart 1967). The other subspecies of *L. natalensis*, i.e. *L. natalensis brauni* (Simroth, 1913), which reportedly has a penial verge of different form, occurs in central and eastern Africa (Forcart 1953). However, in view of the variability in penial shape (Figs 19) exhibited by specimens of the nominate subspecies from KwaZulu-Natal, I have reservations in accepting *brauni* as distinct, even as a subspecies. Forcart (1953) reported further differences between the two subspecies with respect to the width of the foot relative to the hyponotum, but subsequently retracted this (Forcart 1967).

Laevicaulis alte (Férussac, 1821)

Figs 12, 20; Map 3

Vaginulus alte Férussac, 1821: 14. Type loc.: Pondicherry, India.
Laevicaulis alte; Forcart, 1953: 63, figs and map; *idem*, 1967: 514 (further references and synonymy); Bruggen, 1966: 390; *idem*, 1968: 50; Bruggen & Appleton, 1977: 38; Bruggen & Meredith, 1984: 159.

General description: Very similar to the preceding species; most specimens charcoal grey with a thin, pale brownish, longitudinal stripe along dorsal mid-line; hyponotum frequently also dark, sole pale yellowish white. Extended length up to 120 mm, perhaps more. Not reliably distinguished from *L. n. natalensis* without dissection (see above).

Distribution: Known from central Africa (Zaïre, Malawi and Tanzania) to the Eastern Cape (Port St Johns), and also from numerous Asian localities. Thought to be indigenous to Africa, and perhaps originally endemic. Now introduced to many tropical regions of the world. Perhaps less common in KwaZulu-Natal (Map 3) than *L. n. natalensis* and, according to Forcart (1967), usually occurring at lower altitudes (< 550 m), but has been collected at 1100–1200 m in Nkandhla Forest and inland as far as Pietermaritzburg (900 m).

Habitat: Probably very varied, ranging from indigenous forest (coastal lowland and mist-belt *Podocarpus* forests) to suburban gardens; perhaps not able to tolerate such dry conditions as *L. n. natalensis* (Bruggen 1968).

Locality data – KwaZulu-Natal: Environs of Lake Sibaya; Charter's Creek, St Lucia Lake; Nkandhla Forest (mist-belt *Podocarpus* forest); Pigeon Valley Park, Durban (coastal lowland forest); Pietermaritzburg, suburban gardens.

Additional southern African localities: Port St Johns and the Kruger National Park

(also [*fide* Sirgel] Vredendal [S. Namaqualand] and Windhoek [Namibia] – almost certainly introduced, and Katima Mulilo [eastern Caprivi] – perhaps indigenous).

Laevicaulis haroldi Dundee, 1980

Fig. 13; Map 4

Laevicaulis haroldi Dundee, 1980: 119, figs 1, 2. Type loc.: on *Typha* leaves, Stamford Hill, Durban.

General description: Resembles the preceding species in overall appearance, but is longer and thinner, and somewhat wrinkled transversely; colour variable, ranging from dark brown to cream, frequently alternating in bold transverse bands; the upper tentacles are light brown and the lower ones greyish; underside of mantle cream, sole of foot similar, but somewhat translucent. Extended length of largest specimen yet seen is 90 mm.

Distribution (Map 4): Endemic to KwaZulu-Natal, known from Hluhluwe to Umzinto. Has been collected on only three occasions.

Habitat: Few details available, perhaps associated with marsh-land and waterside vegetation.

Known localities: Durban, amongst bulrushes in a vlei (type locality, but site subsequently destroyed to make way for a road); Hluhluwe Game Reserve, on waterside vegetation at Maphumulo; Umzinto, amongst *Agapanthus* plants in garden.

Family Chlamydephoridae

The family Chlamydephoridae is restricted to southern Africa (10 species, all belonging to one genus, *Chlamydephorus*, 9 in South Africa, all endemic), occurring only as far north as Zimbabwe. Two additional taxa were elevated to full species by Forcart (1967). The Chlamydephoridae is southern Africa's only endemic family of non-marine Mollusca (see p. 233). Like the veronicellid slugs they are firm, somewhat leathery and relatively dry to the touch. However, there is no enveloping mantle shield and, characteristically, there is a clearly visible pneumostome near the hind end of the back. There is also a small, flattish, brittle internal shell which lies deep within a pocket in the skin behind and to the left of the pneumostome. The dorsal surface is marked with distinct grooves radiating from the pneumostome, which can be useful in differentiating the various species. Forcart (1967) recorded six species from KwaZulu-Natal, but only four are recognised here (see *C. gibbonsi*), one of which is endemic to the province. These slugs are very secretive and inconspicuous animals, and none are commonly encountered.

This family has long been known as the Aperidae von Moellendorff, 1902 (based on *Apera* Heynemann, 1885). The type species of both *Chlamydephorus* Binney, 1879 and *Apera* is *Chlamydephorus gibbonsi* Binney, 1879, but the older *Chlamydephorus* has previously been rejected in favour of *Apera* because of confusion with *Chlamydophorus* Wagler, 1830 and other misspellings of *Chlamyphorus* Harlan, 1825 (a genus of armadillo). However, such rejection is not justified and *Chlamydephorus* must be given priority (Rosenberg in Richardson 1989: 153). Zilch (1959–60), recognising this priority, used the family name

Chlamydephoridae in place of Aperidae, but this has not met with wide acceptance and use of the name Aperidae has continued (e.g. Forcart 1967, Bruggen 1969 1978). Richardson (1989), Tillier (1989) and Vaught (1989), however, have recently employed the name Chlamydephoridae. Although the ICZN (1985: Art. 40b) states that replacement family group names proposed prior to 1961, on account of synonymy of the type genus, are to be maintained if they have 'won general acceptance', it does not stipulate a course of action when both names have appeared in subsequent literature, as in this instance. Since the family contains only one currently recognised genus for which the valid name is *Chlamydephorus*, I have chosen to use Chlamydephoridae as the family-group name.

Chlamydephorid slugs are thought to have evolved from rhytidid snails (e.g. *Nata* and *Natalina*) and were treated as a subfamily of Rhytididae in a recent classification (Tillier 1989). Like rhytidids they lack a jaw and have a radula characteristic of carnivorous species (i.e. with numerous sharply pointed teeth). This has led to the assumption that chlamydephorids too are carnivores, and although there have been suggestions as to what they may eat (other slugs, snails, earthworms and even millipedes), there do not appear to have been any documented observations on this. However, a specimen of *C. dimidius* kept in captivity at the Natal Museum was observed eating a small specimen of a *Trachycystis* species (Charopidae).

The long narrow shape of most chlamydephorid slugs may be an adaptation for squeezing under stones and logs, through the soil, down burrows in search of prey, and to extracting as much of the viscera as possible from the apical whorls of prey snails. When disturbed, all chlamydephorids contract into a turgid, crescent-shaped to almost circular lump (Fig. 26). In the keeled species the keels seem to become more pronounced and the overall appearance is then very like a piece of bark or wood, or a dried-up leaf.

Genus *Chlamydephorus* Binney, 1879

Type species: *Chlamydephorus gibbonsi* Binney, 1879.

Distribution: Endemic to southern Africa; from the highlands of eastern Zimbabwe through the Kruger National Park, Mpumalanga, and KwaZulu-Natal to the Eastern Cape, with a single outlying species on Table Mountain, Cape Town.

Key to species of *Chlamydephorus* in KwaZulu-Natal

1 Body with distinct longitudinal keels 2
– Body lacking longitudinal keels 3

2 Upper keels gradually converging behind pneumostome and joining to form a short median keel at rear ..... **sexangulus**
– Upper keels diverging in posterior half of body before curving round and joining to create a flat round-ended pad at hind end ..... **burnupi**

3 Colour pattern distinctive, broad pale dorsal region with darker (blackish) border, sides brown; mid-dorsal grooves not conspicuous ..... **dimidius**
– Colour pattern not as above; mid-dorsal grooves conspicuous ..... **gibbonsi**

Chlamydephorus burnupi (Smith, 1892)

Fig. 21; Map 6

Apera burnupi Smith, 1892: 466; Forcart, 1967: 527, figs 1, 4 (further references). Type loc.: Pietermaritzburg area, Natal.

Apera natalensis Collinge, 1900: 3, pl. 1, figs 3, 4, pl. 2, figs 14, 15; *idem*, 1910: 167. Type loc.: Richmond, Natal.

General description: A characteristic species with distinct longitudinal keels along the body and a large flattened area postero-dorsally, in the centre of which lies the respiratory opening; animal humped approximately two-thirds of way along body; body broadest behind this and gently tapering toward head; anterior two-thirds somewhat squarish in cross section; hind margin more or less evenly rounded where upper keels join, these keels strongly scalloped around margin of posterior disc; lower keels, bordering edge of foot, not as strong as upper ones and stop short of the hind end; grooves on dorsal surface conspicuous, rendering posterior section of upper keels crenulate. Orange-brown to dark reddish brown, somewhat paler ventrally; sides frequently with darker, greyish mottling. Extended length up to 80 mm, perhaps more.

Distribution (Map 6): Near endemic; foothills of central Natal Drakensberg to Eastern Cape (Port St Johns). The specimens recorded from Kologha Forest (near Stutterheim), and Bosberg slopes (Somerset East) by Forcart (1967) as *Apera burnupi*, are in fact examples of *C. sexangulus*.

Habitat: Nearly all material available has been collected in mist-belt *Podocarpus* forest, usually under stones and under or in rotting logs. Presumably that found at Port St Johns was in coastal scarp forest.

Locality data – KwaZulu-Natal: Champagne Castle Hotel; Pietermaritzburg; Richmond; Bulwer; Ngele Forest, under stone in leaf-litter, mist-belt *Podocarpus* forest.

Additional localities: Port St Johns.

Remarks: Animals kept in captivity remained largely inactive and showed little interest in eating, despite having been offered items such as small snails (living and dead) and earthworms.

Collinge's figures of his *Apera natalensis* confirm its synonymy with *C. burnupi*.

Chlamydephorus dimidius (Watson, 1915)

Fig. 22; Map 7

Apera dimidia Watson, 1915: 204, pl. 7, figs 7–9, pl. 8, figs 20, 21, 24; Forcart, 1967: 522, fig. 8 (further references). Type loc.: Equeefa Farm [Nkwifa] near Umzinto, KwaZulu-Natal.

General description: Body lacking keels, somewhat flattened dorsally and laterally, giving a subquadrate cross section; tapering gently toward head, more acutely behind pneumostome. Colour pattern evidently characteristic; dorsal region, from head to just behind pneumostome, paler than sides, buff to brown, generally with a darker central portion; pale region bordered laterally by a dark brown (almost black) band on each side, these thin and fragmented in some animals, particularly when animal is extended; sides brown to dark brown, becoming somewhat paler toward ventral margin; sole of foot pale greyish brown, extensively spotted with small dark dots; margin of pneumostome pale; upper tentacles grey-brown, lower ones paler. Texture

of skin reminiscent of snake-skin when animal extended, the somewhat more darkly coloured superficial grooves appearing to divide the skin into scales. Extended length up to 55 mm, perhaps more.

Distribution (Map 7): Evidently endemic to KwaZulu-Natal; known primarily from the coastal region between Durban and the Mtamvuna River, with one inland record from Qudeni Forest (nr Kranskop) at 1400 m.

Habitat: The limited habitat data available indicate that the species is an inhabitant of coastal lowland, coastal scarp, and mist-belt *Podocarpus* forests. Most specimens have been found under fallen logs, but one was also found crawling on a tree trunk in damp weather. Another was obtained from leaf-litter processed in a Berlese funnel trap.

Locality data: Qudeni Forest, nr Kranskop, mist-belt *Podocarpus* forest; Krantzkloof Nature Reserve, coastal scarp forest; Pigeon Valley Park, Durban, coastal lowland forest; Nkwifa (Equeefa), Umzinto; ?Port Shepstone; Mtamvuna Gorge, coastal lowland section of forest.

Remarks: When contracted in the crescentic defensive pose, the animal peculiarly tucks the tail of the foot under the hind end. Although the colour pattern is characteristic, the density of pigmentation varies considerably, some specimens, particularly small ones, appearing extremely dark. The black lateral lines are sometimes divided into oblique dashes towards the posterior.

Chlamydephorus gibbonsi Binney, 1879

Figs 24–26; Map 8

Chlamydephorus gibbonsi Binney, 1879: 331, pl. 2, figs a, b. Type loc.: 'Umgeni Valley', KwaZulu-Natal.
Apera gibbonsi; Watson, 1915: 193, pl. 7, figs 1, 2, pl. 8, figs 14, 15; Collinge, 1910: 165; Forcart, 1967: 524 (further references), figs 10, 12; Bruggen & Appleton, 1977: 33.
Apera gibbonsi rubella Watson, 1915: 197, pl. 7, figs 3–5, pl. 8, figs 16, 17. Type loc.: Equeefa Farm [Nkwifa] near Umzinto, KwaZulu-Natal.
Apera gibbonsi gracilis Watson, 1915: 199, pl. 7, fig. 6. Type loc.: Equeefa Farm [Nkwifa] near Umzinto, KwaZulu-Natal.
Apera gibbonsi lupata Watson, 1915: 200, pl. 8, figs 18, 19. Type loc.: Port Shepstone, KwaZulu-Natal.
Apera gibbonsi lupata var. *duplex* Watson, 1915: 201. Type loc.: Port St Johns, Eastern Cape.
Apera dimidiata (*sic*); Forcart, 1963: 109.
Apera rubella; Forcart, 1967: 522, figs 5, 7, 11, 13.
Apera gracilis: Forcart, 1967: 523.

General description: Body more or less cylindrical, tapering gently toward head, more acutely behind pneumostome; lacking longitudinal keels; skin coarsely reticulated with two well-developed longitudinal grooves in centre of back, uniting 4–5 mm in front of pneumostome; grooves radiating from pneumostome conspicuous, some forked. Colour variable, ranging from dull orange mottled with brown (with an ill-defined paler mid-dorsal longitudinal band) to dark grey-brown with a distinct, pale brown, mid-dorsal line; ventral region and sole yellow to bright orange-yellow. Extended length up to 110 mm.

Distribution (Map 8): Near endemic; Zululand (Ngome Forest) to north-eastern Cape (Port St Johns), inland as far as Kranskop and Pietermaritzburg.

Habitat: Found under logs and stones, and amongst leaf-litter in a range of habitats from moist indigenous forests (dune, coastal, coastal scarp and mist-belt *Podocarpus*) to thornveld. Rarely encountered, but evidently subterranean and perhaps not uncommon. As with earthworms, heavy rains appear to force these animals to the soil surface and they may then be found crawling in the open above ground. Numerous specimens were found in this way in a thornveld garden in Ashburton (Pietermaritzburg) after the heavy rains of early 1996 (Miller, *pers. comm.*), where they were being preyed upon by hadedah ibises (*Bostrychia hagedash* Latham, 1790). The specimen recorded from cow dung in Pietermaritzburg (Forcart 1963 – as *Apera dimidiata* [*sic*]), was presumably searching for insect larvae or worms.

Locality data – KwaZulu-Natal: Environs of Lake Sibaya; Ngome Forest, mist-belt *Podocarpus* forest, deep in rotting debris under large fallen tree trunk; Hluhluwe Game Reserve; Hlabisa; Umfolozi Game Reserve, in disturbed *Spirostachys* woodland and on road in open grassy woodland, during rain; Cape Vidal, dune forest, in leaf-litter; Charter's Creek; Mapelane, dune/coastal forest, in leaf-litter; Richard's Bay; Ngoye Forest; Middledrift, nr Kranskop; Kranskop; 'Umgeni Valley'; Chase Valley, Pietermaritzburg, crossing road; Payn St, Pietermaritzburg, under stone after heavy rains; Ashburton, thornveld garden, crawling on driveway after heavy rains; Hillcrest (St Helier); Krantzkloof Nature Reserve, coastal scarp forest, in leaf-litter; Clifton Canyon, Hillcrest, coastal scarp forest, under stone in leaf-litter; Bellair, Durban, coastal bush; Nkwifa (Equeefa), Umzinto; Ifafa; Port Shepstone.

Additional localities: Port St Johns.

Remarks: Forcart (1967) elevated two of the subspecies proposed by Watson (1915) to full species (*rubella* and *gracilis*), but added little to Watson's observations in support of this. The taxon *rubella* reportedly differs from *gibbonsi* in respect to characters of the radula and male reproductive tract. The penis is supposedly long and twisted and the penial retractor muscle short in *rubella*, whilst in *gibbonsi* the penis is short and distally curved, and the penial retractor relatively long. The radula in *gibbonsi* supposedly possesses a central tooth, but in *rubella* (including *lupata* and *lupata* var. *duplex*) this is vestigial or absent. However, my dissection of freshly collected material indicates the shape of the penis and its length relative to the penial retractor muscle to be variable. Similarly, presence or absence of a central tooth in the radula is not clear-cut when some individuals retain a vestigial central tooth. Consequently, I cannot reliably separate Forcart's two taxa based on the characters given in his key (Forcart 1967).

The taxon *gracilis* is reportedly narrower, more sharply pointed posteriorly, and reaches maturity at a smaller size than either *gibbonsi* or *rubella*. Having seen the extent to which these animals can vary their shape in life, I am highly dubious of drawing conclusions based on the shape of preserved animals. Similarly, to base a taxonomic decision on size at maturity with so little material available (two recorded specimens of *gracilis*) is scarcely justifiable.

Resolution of uncertainties surrounding these taxa must await more thorough investigation using fresh material and including data on habitat and observations of *in vivo* coloration. Since I have been unable to separate different species, I have treated all newly collected specimens under the oldest available name – *gibbonsi* – and treat it as a single species with respect to habitat and distribution data.

Although material from forests is usually paler and more uniform in colour, and that from drier habitats (thornveld and *Spirostachys* woodland) usually dark with a pale mid-dorsal line, specimens with the latter colour pattern have also been found in forested habitats and there are many of intermediate colour. In view of the colour variability exhibited by *C. sexangulus* (see below) and its occurrence in an equally wide range of habitats, there seems no justification for assuming that similar variation in *gibbonsi* is indicative of more than one species.

Chlamydephorus sexangulus (Watson, 1915)

Fig. 23; Map 9

Apera sexangula Watson, 1915: 213, pl. 7, figs 12, 13; Forcart, 1967: 528, fig. 3 (further references). Type loc.: Port Shepstone, Natal.
Apera burnupi (*non* Smith, 1892); Collinge, 1900: pl. 1, figs 5, 6; *idem*, 1910: 166.

General description: A striking species that resembles *C. burnupi* in possessing prominent longitudinal keels, but is more slender and tapers to an acute angle posteriorly, without a disc-like expansion between the two upper keels. Despite its name, there are really only four keels, but the body is also angled where the sides of the foot meet the sole, and it thus appears somewhat hexagonal in cross section. Upper keels join behind pneumostome to form a single short keel which runs to posterior of foot; lateral keels extend along entire length of body, about halfway between edge of foot and upper keels; the surface bears conspicuous grooves which cause some roughening of the upper keels at the hind end. Orange-brown to chestnut or purplish brown, some individuals also mottled with dark greyish brown, particularly on sides, and with paler keels; foot colour contrasting with that of body, cream to pale yellow. Extended length 100 mm or more.

Distribution (Map 9): Zululand to the Eastern Cape (Bosberg slopes, Somerset East), 0–1250 m, but not yet recorded further than 70–80 km inland. Specimens from the Eastern Cape (Kologha Forest and Bosberg slopes) recorded by Forcart (1967) as *Apera burnupi*, are in fact *C. sexangulus*.

Habitat: Little precise information available, but most specimens have been collected in coastal lowland, coastal scarp and mist-belt *Podocarpus* forests. The living specimens seen by me were found in leaf-litter or under large stones lying in leaf-litter on the forest floor. However, a specimen found under a stone in thornveld in the Nkwalini Valley, indicates that the species is not confined to forests.

Locality data – KwaZulu-Natal: Ngome Forest, mist-belt *Podocarpus* forest; Cape Vidal, dune forest; Mapelane, dune forest; Mtunzini, *Ficus trichopoda* forest; Mfuli Game Reserve, Nkwalini Valley, 'thornveld'; Ngoye Forest, coastal scarp forest; Nkandla Forest, mist-belt *Podocarpus* forest; Middledrift, Thukela Valley; Ntunjambili, near Kranskop, indigenous forest; Lilani area near Ahrens, Kranskop; Hilton Road, Pietermaritzburg, mist-belt *Podocarpus* forest; Shongweni Resource Reserve, thick valley bushveld and woodland; Hawaan Forest, Umhlanga, coastal lowland forest; Kelso Junction; Port Shepstone; Mtamvuna Gorge, coastal lowland section of forest.

Additional localities: Bosberg Slopes near Somerset East; Kologha Forest near Stutterheim, 900–1200 m; Port St Johns.

Remarks: Behaviour similar to *C. burnupi*, but evidently more active. Collinge (1900) misidentified material of *C. sexangulus* as *C. burnupi*, at the same time describing material of the true *C. burnupi* as a new species, *Apera natalensis*.

Family Urocyclidae

The Urocyclidae is a morphologically diverse family and has traditionally been split into two subfamilies (e.g. Zilch 1959–60), Trochozonitinae for snail-like genera (with visceral mass distinct from the foot and with a more or less obvious external shell, but no stimulatory organ) and Urocyclinae for slug-like forms (where visceral mass incorporated in the foot and the shell reduced to an internalised vestige, but a stimulatory organ is present). Although this division is not without exceptions and the subfamilies are probably not monophyletic, it has a certain practicality and seems to be the best available at present (Van Goethem 1977). A third subfamily, Gymnarioninae, was proposed by Van Mol (1970) for *Gymnarion* Pilsbry, 1919, which he considered sufficiently distinct from other snail-like urocyclids to warrant separation. However, the Gymnarioninae was not subsequently mentioned by Van Goethem (1977). More recently, Tillier (1989) seemed to suggest that the urocyclids be grouped with genera such as the Australasian *Helicarion* Férussac, 1821, in one large family, the Helicarionidae, but this has not yet been adequately debated in the literature.

Both snail-like and slug-like urocyclids occur in KwaZulu-Natal. Though more numerous in terms of recorded species, the former all evidently belong to one genus, *Sheldonia* Ancey, 1887 (although *Trochonanina mozambicensis* (Pfeiffer, 1855) may ultimately prove to range south into the province). In contrast three genera of slug-like forms occur in the region, each with only one species

Subfamily Urocyclinae

Herbivorous slugs similar in overall appearance to the European limacid and arionid slugs and similarly slimy; characterised by the possession of a short, tail-like, caudal appendage above the opening of the caudal gland at the posterior limit of the body and a pore or notch overlying the internal shell at the posterior end of the mantle shield (although neither the appendage nor the pore are particularly obvious). The internal shell is thin and fragile, and may be more or less symmetrical about its mid-line or show distinct spiral coiling; the sole of the foot is longitudinally tripartite. Like many arionid slugs, urocyclids can contract into a hemispherical hump and are particularly prone to do so when disturbed.

The subfamily is endemic to the moister areas of sub-Saharan Africa, Madagascar, the Comores and the islands of the Gulf of Guinea. In southern Africa its representatives are confined to the warmer eastern regions.

Key to species of Urocyclinae in KwaZulu-Natal (based on external features)

The various urocycline slug genera are defined by anatomical characters, primarily those of the genital apparatus, and available keys (Forcart 1967, Van Goethem 1977) require dissection of the animal. Fortunately, the only species known to occur in

KwaZulu-Natal are relatively distinct and can be separated using external characters. However, since a number of additional urocycline slugs are known from neighbouring countries, anyone with a specimen not matching one of the descriptions given below should refer to Forcart (1967) and Van Goethem (1977). It is quite possible that additional urocycline taxa, currently unknown south of Zimbabwe and Mozambique, may prove to occur in northern KwaZulu-Natal.

1 Body posterior to mantle with a light and dark longitudinal band on each side, delimiting a brownish, medio-dorsal, elongate, V-shaped area. ...**Urocyclus kirkii**
– Body not so marked 2
2 Mantle usually spotted or irregularly patterned with darker markings; body posterior to mantle lacking well defined markings, but perhaps with a pale mid-dorsal line; animal essentially grey-brown .....**Atoxonoides meridionalis**
– Mantle typically patterned with reticulate to honey comb-like network and with a darker longitudinal band on each side; body posterior to mantle with anatomising longitudinal lines interconnected by finer transverse ones; animal frequently bright yellow, less often brownish or greyish.....**Elisolimax flavescens**

Genus *Atoxonoides* Van Goethem, 1973

Type species: *Atoxon meridionalis* Forcart, 1967.

Distribution: Known only from KwaZulu-Natal and the eastern highlands of Zimbabwe.

Atoxonoides meridionalis (Forcart, 1967)

Figs 27, 28; Map 5

Atoxon meridionalis Forcart, 1967: 549, figs 32–34, 36. Type loc.: Eshowe, KwaZulu-Natal.
Atoxonoides meridionalis; Van Goethem, 1977: 162, figs 310–317, map 11.

General description: A medium-sized, greyish brown slug; mantle covered with fine, close-set, rounded granules, grey-brown, spotted or irregularly reticulated with darker markings, sometimes with a dark, discontinuous, longitudinal line on each side, below which it is paler; antero-lateral portion of foot similarly pale; body posterior to mantle more uniformly coloured, dark grey-brown, usually with a lighter brownish longitudinal stripe along dorsal mid-line, paler towards foot; when hunched up in resting pose posterior region of body may appear slightly keeled in mid-line; optic tentacles grey-brown. Extended length up to 50 mm, perhaps more. Occasional specimens have a pale, almost milky white ground coloration.

Distribution (Map 5): From the eastern highlands of Zimbabwe to Zululand (Eshowe); from sea level to 1200 m (Zimbabwe).

Habitat: Little information is available, but in Hluhluwe Game Reserve, where the species is evidently common, it has been collected under fallen bark and amongst leaf-litter in coastal scarp forest and pockets of woodland in more open bushveld.

Locality data – KwaZulu-Natal: Hluhluwe Game Reserve; Charters Creek, St Lucia; Eshowe.
Additional localities: Vumba Mountains, eastern highlands of Zimbabwe.

Figs 27–28. *Atoxonoides meridionalis* (Forcart, 1967); Hluhluwe Game Reserve. **27**. Actively crawling. **28**. Animals huddled together to conserve moisture, in leaf-litter under fallen bark.

Remarks: Forcart originally described this slug as stout, but the only material available to him was preserved. Although humped in its resting state and when disturbed, actively crawling animals are not noticeably more stout than other urocyclids (Fig. 27). The mucous produced by these slugs is particularly slimy and sticky.

Genus *Elisolimax* Cockerell, 1893

Type species: *Elisa bella* Heynemann, 1882.

Distribution: Eastern and south-eastern Africa, Madagascar and the Comores.

Elisolimax flavescens (Keferstein, 1866)

Figs 14, 15; Maps 10, 11

Parmarion flavescens Keferstein, 1866: 70, pl. 2, figs 1–8. Type loc.: Inhambane, southern Mozambique.
Aspidophorus fasciatus Martens, 1879: 736. Type loc.: Rio Quellimane [Quelimane], Mozambique.
Urocyclus pallescens Cockerell, 1891: 101; Collinge, 1910: 162. Type loc.: Port Natal [Durban].
Urocyclus flavescens; Collinge, 1910: 162; Connolly, 1939: 166.
Urocyclus fasciatus; Collinge, 1910: 162; Forcart, 1963: 107.
Urocyclus (Elisolimax) flavescens; Forcart, 1967: 542, figs 25–31 (further references and synonymy); Bruggen, 1968: 51; Bruggen & Appleton, 1977: 37, pl. 4.
Atoxon cooksoni Forcart, 1967: 553, figs 38–40 (see Van Goethem 1977). Type loc.: Chiluvo Forest, Mozambique.
Elisolimax flavescens; Van Goethem, 1977: 215, pl. 3, figs 11, 12, figs 492–515, map 14 (further references and synonymy); Nel, 1984.

General description: Coloration variable (perhaps polymorphic), but commonly bright yellow, less often greenish yellow, brownish yellow or greyish; mantle typically patterned with reticulate to honey comb-like network and with a darker longitudinal band on each side; body posterior to mantle with anastomising longitudinal lines interconnected by finer transverse ones, greyish and brownish specimens frequently with a pale dorso-lateral longitudinal stripe on each side. Extended length up to 60 mm, perhaps more.

Distribution (Maps 10, 11): From Zimbabwe to the Kruger National Park, Mpumalanga and southern Mozambique south to Mtamvuna Gorge (range extension), from sea level to 1400 m. Extending inland in KwaZulu-Natal as far as Pietermaritzburg and Muden.

Habitat: Tolerates lower levels of humidity than most urocyclids and is very catholic

with respect to habitat, occurring in forests, thornveld, valley bushveld, grassland and gardens; under logs and stones, on tree trunks and frequently in exposed positions on vegetation. Forcart (1967) has even recorded it on seaweed at Inhaca Island.

Locality data – KwaZulu-Natal (Map 11): Material is available from numerous localities in the lower-lying eastern part of KwaZulu-Natal. The southernmost distribution record was previously Port Shepstone (Van Goethem 1977), but additional specimens have since been collected in the Mtamvuna Gorge on the border between KwaZulu-Natal and Transkei (Eastern Cape). Doubtlessly the species will prove to range further south into Pondoland.

Additional South African localities: Barberton and Kruger National Park.

Remarks: By far the most common urocyclid slug in KwaZulu-Natal. The brightness of the yellow colour variety of this slug could well act as a warning to potential predators, indicating noxious secretions and foul taste. Nonetheless, Bruggen & Appleton (1977) reported the species being eaten by the variegated slug-eater snake, *Duberria variegata* (Peters, 1854), and it is readily eaten by carnivorous snails such as *Natalina cafra* (Férussac, 1821) (*pers. obs.*). Such predators, however, almost certainly use non-visual cues to locate prey. From the evidence available it appears that at any one locality all specimens are of similar coloration. Known to cause damage to banana and citrus crops (Bedford 1978, Jones 1981).

Genus *Urocyclus* Gray, 1864

Type species: *Urocyclus kirkii* Gray, 1864.

Distribution: East Africa, from Ethiopia to KwaZulu-Natal.

Note: *Limax kraussianus* Heynemann, 1862, based on material collected by Krauss in Cape Town, was subsequently referred to *Urocyclus* and recorded from 'Natal' by Heynemann (1885). However, Van Goethem (1977) rejected this Natal record and tentatively placed the taxon in *Elisolimax*, at the same time considering it a *species inquirenda*. Sirgel (1985) subsequently discussed the matter in detail and concluded that *kraussianus* was probably a species of his new genus *Ariostralis*, but proposed that it be considered a *nomen dubium* in view of the fact that published descriptions were inadequate and the type material is now lost.

Urocyclus kirkii Gray, 1864

Figs 29, 30; Map 5

Urocyclus kirkii Gray, 1864: 251; Collinge, 1910: 161; Connolly, 1939: 166; Forcart, 1963: 104, 107; *idem*, 1967: 535, figs 20–24; Van Goethem, 1977: 286, pl. 4, figs 5–8, 696–715, map 18 (further references and synonymy); Bruggen, 1993: 108. Type loc.: near mouth of Zambesi River, Mozambique.

General description: A medium to large, greyish slug with characteristic colour pattern; ground colour pale grey, body posterior to mantle with a medio-dorsal, mid-brown to grey-brown, elongate V-shaped mark, bordered on each side by two longitudinal bands, the inner one buff to fawn-grey, the outer one charcoal grey to black; sides of foot pale, usually with rather ill-defined dark spots, sometimes connected by fine lines radiating from mantle to sole; foot fringe pale with numerous

regularly spaced vertical lines; mantle finely granular, dark grey to brownish grey, finely reticulated with dark lines, sometimes with a rather indistinct longitudinal stripe on each side, paler below this; optic tentacles dark grey-brown. Posterior of body with a slight mid-dorsal keel when in contracted state. Extended length up to 120 mm, perhaps more.


Figs 29–30. *Urocyclus kirkii* Gray, 1864; Umzumbe. **29**. Actively crawling. **30**. Resting pose.

Distribution (Map 5): Known only from a small number of localities in southern Tanzania, southern Malaŵi, Mozambique and Zimbabwe; southerly distribution limit here extended to KwaZulu-Natal (Umzumbe), where it has been collected at a number of localities in the coastal region.

Habitat: Inhabits relatively undisturbed, moist bush and forest, but has also been found in gardens in the Durban area and on the south coast.

Locality data – KwaZulu-Natal: Burman Bush, Pigeon Valley Park and Kenneth Stainbank Nature Reserve (all coastal lowland forest in the Durban area); Durban North, in garden; Westville, in garden; Umzumbe, in garden.

Additional localities: Southern Tanzania, Malaŵi (Blantyre), eastern highlands of Zimbabwe and forested areas in central Mozambique.

Remarks: This is the first confirmed record of *U. kirkii* from KwaZulu-Natal. The previous records of Sturany (see Connolly 1939) and of Forcart (1963) from Durban, were based on material that was subsequently shown to be *E. flavescens* and a juvenile of a species of *Deroceras*, respectively (Forcart 1967) and were not accepted by Van Goethem (1977). The presence of a posterior mantle pore and a caudal appendage renders even juvenile *U. kirkii* easily separable from the introduced limacids and agriolimacids. They may not, however, be so easily distinguished from juveniles of the grey colour variety of *E. flavescens*.

INTRODUCED SPECIES

Family Arionidae

Superficially similar to limacid slugs, but pneumostome in front of mid-point of mantle shield; mantle shield finely granular, not grooved like a finger-print; posterior region lacking a permanent longitudinal keel in mid-line; internal shell small to vestigial (sometimes reduced to a few calcareous granules); many species can contract longitudinally to a great extent, such that they become almost hemispherical.

Generally herbivorous, feeding on plant material and fungi, although some may scavenge on waste matter and carrion.

Three subfamilies occur in South Africa, two of these, the Oopeltinae and Ariopeltinae are indigenous, but are restricted to the Cape fynbos and the Hottentots Holland mountains respectively (Sirgel 1986). The third subfamily, Arioninae, includes species occurring in KwaZulu-Natal, but all are introduced from Europe. Only two species, *A. intermedius* Normand, 1852, and *A. hortensis* Férussac, 1819, have been recorded in South Africa and neither is commonly found (Sirgel, *pers. comm.*). The former is widespread, whereas the latter has been reported only from the south-western Cape.

Genus *Arion* Férussac, 1819

Type species: *Limax ater* Linnaeus, 1758 (by subsequent designation (Flemming 1822), but see Barker 1979: 416).

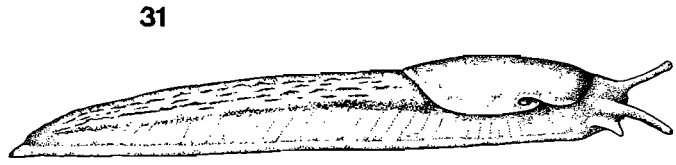
Distribution: Primarily the western Palaearctic, but introduced to many temperate regions beyond this.

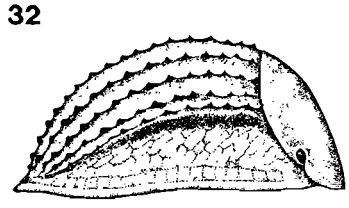
Arion intermedius Normand, 1852

Figs 31, 32

Arion intermedius Normand, 1852: 8; Altena, 1966: 271. Type loc.: Valenciennes, France.
Arion minimus Simroth, 1885: 237, 289, pl. 7, fig. 41, pl. 11, figs 18–23; *idem*, 1907: 794. Type loc.: Niederlausitz and Harthwalde, near Leipzig.
Arion fuscus; Collinge, 1910: 170 (see Connolly 1939: 183).
Arion (Microarion) intermedius; Barker, 1979: 416 (further references and synonymy).

General description: A small slug (extended length 20 mm); yellowish white to grey in colour, sometimes with an indistinct longitudinal band on each side; head and tentacles darker; mucus yellow. When contracted the dorsal surface develops a characteristic, somewhat prickly appearance (Fig. 32).





Figs 31–32. *Arion intermedius* Normand, 1852. **31**. Actively crawling. **32**. Contracted animal, showing characteristic prickly dorsal surface from which its common name, hedgehog slug, is obviously derived. [Drawings based on illustrations in European literature].

Distribution: Indigenous to western Europe; introduced to South Africa prior to 1898 (Bruggen 1964), but has not spread widely and may not have established viable populations. Also introduced to Australia and New Zealand.

Habitat: In Europe its habitat preferences are wide, including acidic habitats and even conifer plantations (Killeen 1992), but no details are available concerning South Africa. It has penetrated native scrubland and forests in New Zealand (Barker 1982).

Locality data – KwaZulu-Natal: Recorded only from Pietermaritzburg. No new material seen by the author.

Additional South African localities: Cape Town and environs.

Remarks: Has been reported to occur in large numbers in agricultural crops in Europe, but its status as a pest remains uncertain (South 1992).

Family Milacidae

Resembling limacid slugs, but with the dorsal keel extending from the tip of the tail to the hind margin of the mantle; mantle also with a characteristic, horseshoe-shaped groove; pneumostome situated on right, behind mid-point of mantle; foot divided longitudinally into three bands, the central one with a herring-bone pattern; tail pointed; internal shell symmetrical about its long axis.

The family Milacidae is represented in South Africa only by the introduced *Milax gagates* (Draparnaud, 1801). It is quite possible, however, that other milacids have been or will be introduced, but have not yet been recorded. Consequently, it would be safest to consult the literature on European slugs before making definitive identifications. These other species differ from *M. gagates* in having different coloration, being spotted, having more coarsely textured skin or a pale rim around the pneumostome, or a combination of these characters.

Genus *Milax* Gray, 1855

Type species: *Limax gagates* Draparnaud, 1801.

Distribution: South-western Palaearctic, but introduced to many temperate regions beyond this.

Milax gagates (Draparnaud, 1801)

Fig. 33; Map 12

Limax gagates Draparnaud, 1801: 100. Type loc.: ?near Montpellier, France.
Amalia gagates; Collinge, 1901: 230.
Milax gagates; Collinge, 1910: 161 (record from Pietermaritzburg); Connolly, 1939: 180; Altena, 1966: 289; Els, 1974; Wiktor, 1987: 202 (further references and synonymy).

General description: A relatively smooth-skinned, dark grey to black slug (rarely paler brown), easily recognised by the prominent keel running from the tail to the hind end of the mantle and the horseshoe-shaped groove on the mantle itself; the

Fig. 33. *Milax gagates* (Draparnaud, 1801); Mooi River.

coloration, though paler towards the foot, is relatively uniform (not spotted or banded); mucus clear. Extended length up to 60 mm.

Distribution: Indigenous to the coastal areas of the western Mediterranean; introduced to southern Africa prior to 1873. Also introduced to many other parts of the world including northern Europe, America, Australia, New Zealand, Japan and oceanic islands.

Locality data – KwaZulu-Natal (Map 12): First recorded in KwaZulu-Natal (Pietermaritzburg) by Collinge (1910), but not reported subsequently. Dr A. C. van Bruggen collected a second specimen in a garden in Pietermaritzburg in 1975 and a third specimen has recently been found in a garden near Mooi River in the midlands.

Additional South African localities: Cape Town and environs, Stellenbosch, Ashton, Storms Vlei, Ladismith, George, Port Elizabeth and East London.

Habitat: Few details available for southern African material, but known elsewhere to be an ecologically tolerant species occurring in various climatic zones and a wide range of habitats including agricultural land; under logs, stones and other objects lying on the ground in moist or shaded areas. Frequently synanthropic.

Remarks: The specimen from Mooi River illustrated in Fig. 33, though undoubtedly a milacid, was juvenile (extended length ± 30 mm) and has been identified as *M. gagates* solely on the grounds that this is the only species of *Milax* yet recorded from South Africa (Altena 1966). The identity of the specimen collected from Pietermaritzburg by van Bruggen was determined by Altena. Wiktor (1987) has cautioned against confusion of *M. gagates* with the very similar *M. nigricans* (Schulz, 1836), also originally from coastal areas of the Mediterranean.

This species may well prove to be widespread in KwaZulu-Natal, in gardens and other habitats modified by humans. It has the potential to become a pest and is known to attack maize seeds and seedlings (South 1992).

Family Limacidae

Mantle shield positioned anteriorly and with fine concentric ridges, somewhat

resembling a finger-print; central point of finger-print situated in mid-line; pneumostome on right, behind mid-point of mantle shield (cf. Arionidae); posterior region keeled in mid-line (not always obvious), but keel not extending to mantle (cf. Milacidae); tail gently sloping; sole of foot divided into three longitudinal muscular bands; thin fragile internal shell retained under mantle; intestine with five loops; herbivorous, frequently synanthropic.

No limacid slugs occurring in South Africa are indigenous and all are thought to have been introduced from Europe amongst imported vegetation. Two genera occur in KwaZulu-Natal, *Limax* and *Lehmannia*. They resemble agriolimacids (which are sometimes also treated as limacids), but are larger (generally > 40 mm in length) and have a gently sloping tail. The agriolimacids (genus *Deroceras*) are generally < 40 mm in length and have a steeply sloping tail. Furthermore, in limacids the mantle finger-print is centred about the mid-line, whilst in agriolimacids it is displaced to the right of the mid-line, just above the pneumostome.

There has been much confusion over the generic affinities of *Limax flavus*. It is a senior synonym of *Limax breckworthianus* Lehmann, 1864, the type species of the taxon *Limacus* Lehmann, 1864, but this is usually treated at subgeneric level and authors have vacillated as to whether it should be referred to *Limax* or *Lehmannia*. Current opinion suggests that *Limacus* is more correctly placed in *Limax* since it shows greater anatomical similarity with that taxon than with *Lehmannia*, notably a long coiled penis, near absence of a penial flagellum, and a clearly bipartite oviduct (*fide* Backeljau). It differs from *Limax s. str.* in having a long rectal caecum (as does *Lehmannia*) and in the spermathecal duct being implanted on the oviduct rather than on the penis (as in both *Limax s. str.* and *Lehmannia*).

Key to genera of Limacidae in KwaZulu-Natal

1 Mantle spotted or marbled with blackish markings or entire slug greyish green with yellowish spots; not longitudinally banded; frequently more than 75 mm in length.....**Limax**

– Pale greyish buff to pinkish brown, usually with darker longitudinal bands on both mantle and body; relatively small (length up to 50 mm).....**Lehmannia**

Genus *Limax* Linnaeus, 1758

Type species: *Limax maximus* Linnaeus, 1758.

Distribution: Primarily the western Palaearctic, but introduced to many temperate regions beyond this.

Key to species of *Limax* in KwaZulu-Natal

1 Body greyish green with yellowish spots; mantle similarly patterned; rectum with a long caecum. .....**flavus**

– Body pale brown to grey; mantle spotted or marbled with blackish markings; rectum lacking a caecum .....**maximus**

Limax flavus Linnaeus, 1758

Fig. 16; Map 12

Limax flavus Linnaeus, 1758: 652; Collinge, 1910: 160; Connolly, 1939: 176; Quick, 1960: 184, pl. 2, fig. 22, text fig. 14; Forcart, 1963: 107; Winter, 1997: 40.
Limax (Limacus) flavus; Altena, 1966: 290.
Lehmannia (Limacus) flava; Altena & Smith, 1975: 77, figs 8 a–c; Barker, 1979: 431, fig. 12, not 13 as indicated.

General description: A rather striking species with a yellowish ground colour overlain with greyish or greenish mottling, giving the appearance of a grey-green slug with yellow spots; mantle similarly patterned; tentacles bluish; no longitudinal banding on body or mantle; extended length 75–100 mm, perhaps more.

Distribution: Indigenous to south and western Europe and North Africa, introduced to South Africa prior to 1900; in KwaZulu-Natal known from the coast to Pietermaritzburg (Map 12). Also recorded from Gauteng and the Western Cape and introduced also into Madagascar, North and South America, and Australasia.

Habitat: Synanthropic; not uncommon in gardens, compost heaps, out-buildings and even kitchens, but does not seem to have spread far into the natural environment.

Locality data – KwaZulu-Natal: Mooi River, in garden of small-holding; Pietermaritzburg, numerous localities, mainly on moister western side of city; Shaka's Rock, Umhlali, coastal bush; Durban, suburban garden in Glenwood.

Additional South African localities: Cape Town, Ladismith area, Port Elizabeth, Smithfield (Free State) and Pretoria.

Remarks: Although recorded from few localities, this slug is probably common in the larger urban centres.

Limax maximus Linnaeus, 1758

Fig. 34

Limax maximus Linnaeus, 1758: 652; Collinge, 1901: 229; Connolly, 1939: 175; Quick, 1960: 191, pl. 2, fig. 24; Forcart, 1963: 107. Type loc.: Sweden.

General description: A potentially very large slug (extended length 100–200 mm); colour pattern variable, but frequently pale brown to grey with 2–3 darker longitudinal bands on each side of body, sometimes broken up into spots; mantle spotted or marbled with darker coloration, but not banded; tentacles uniform pinkish to reddish brown, without spots. Connolly (1939) reported Cape Town specimens to be pale salmon coloured with irregular dark spots on the mantle and longitudinal rows of spots, coalescing into bands, on the remainder of the body.

Fig. 34. *Limax maximus* Linnaeus, 1758 (drawing based on illustrations in European literature).

Distribution: Indigenous to southern and western Europe; introduced to South Africa prior to 1900. Populations also established in North America, Australia and New Zealand.

Habitat: No details available for South African material, but in Europe commonly found in woods, hedgerows, waste ground and gardens.

Locality data – KwaZulu-Natal: Pietermaritzburg (Forcart's original material, no new material available).

Additional South African localities: Cape Town.

Remarks: The only South African records are Pietermaritzburg and Cape Town, but this probably reflects nothing more than collecting effort. It is clear, however, from the lack of recent records that the species is not common in South Africa and may not have established itself. Puzzlingly, *L. maximus* was not covered by Altena (1966) in his discussion of the Limacidae in South Africa. Whether the species attains as large a size in South Africa as it does in Europe is not known. Evidently not a major pest species (South 1992).

Sirgel (*pers. comm.*) has questioned the identity of records of *L. maximus* in South Africa, noting that no new material has come to light in either KwaZulu-Natal or the Western Cape, and that specimens of *L. flavus* are sometimes pale salmon coloured with darker spots.

Genus *Lehmannia* Heynemann, 1862

Type species: *Limax marginatus* Müller, 1774.

Distribution: Primarily the western Palaearctic, but introduced to many temperate regions beyond this.

Key to species of *Lehmannia* in KwaZulu-Natal

1 Penis relatively short, with a short, blunt-ending appendage (Fig. 38)..... **valentiana**

– Penis longer and lacking an appendage (Fig. 37) ..... **nyctelia**

Lehmannia nyctelia (Bourguignat, 1861)

Figs 35–37; Map 12

Limax nyctelius Bourguignat, 1861: 305, pl. 2, figs 3, 4; Connolly, 1939: 176; Quick, 1960: 200, fig. 17, b, c & e; Forcart, 1963: 107. Type loc.: Algeria.
Limax (Limacus) nyctelius; Altena, 1966: 290; Bruggen & Appleton, 1977: 36.
Lehmannia (Lehmannia) nyctelia; Altena & Smith, 1975: 75; Barker, 1979: 431, fig. 12.

General description: Overall colour pale greyish buff to pinkish brown, somewhat translucent; a pair of dark longitudinal bands running down the body, one on each side of the mid-line; similar longitudinal bands on the mantle; optic tentacles dark; posterior keel short and not particularly obvious; mucus colourless. Extended length up to 50 mm.

Distribution: Indigenous to North Africa and perhaps also south-eastern Europe; now more widely spread in Europe, North America, Australia and New Zealand. Introduced to South Africa prior to 1939; recorded from few localities in KwaZulu-


Figs 35–36. *Lehmannia nyctelia* (Bourguignat, 1861); Pietermaritzburg. **35**. Actively crawling. **36**. Animals huddled together to conserve moisture, amongst fallen leaves.

Natal (Map 12), but probably more widely distributed, particularly in urban areas.

Habitat: Not uncommon in gardens, but also recorded from rural regions and game reserves. Under logs, stones, flower pots and other objects lying on the ground, particularly in shaded areas. Also in and around compost heaps (often together with *L. valentiana*). Altena & Smith (1975) recorded the species as being common in cleared open country and modified bush in Australia, but less abundant in suburban gardens.

Locality data – KwaZulu-Natal: Mbazwana; Hluhluwe Game Reserve; Pietermaritzburg, suburban gardens, under stones and amongst compost.

Additional South African localities: Cape Town, Ceres, Grahamstown and Bloemfontein.

Remarks: Cannot be reliably separated from *L. valentiana* without dissection (see key). There are a number of other European species very similar to *L. nyctelia* and *L. valentiana* [e.g. *Lehmannia marginata* (Müller, 1774)] which may also have been introduced to KwaZulu-Natal, but which have not yet been recorded. These must also be borne in mind when identifying relatively small, pale, longitudinally banded limacid slugs. Readers should refer to European texts such as Kerney and Cameron (1979) and Quick (1960) for further information on identification. *L. nyctelia* has rarely been cited as a pest (South 1992).

Lehmannia valentiana (Férussac, 1821)

Fig. 38

Limax valentianus Férussac, 1821: 21; Stears, 1974; Kerney & Cameron, 1979: 211.
L. poirieri Mabille, 1883: 52; Quick, 1960: 197, pl. 1, fig. 14.
Limax (Lehmannia) valentianus; Waldén, 1963: 71; Altena, 1966: 292; Bruggen, 1968: 51.

General description: External characters very similar to *L. nyctelia* (Figs 35 & 36), and has been found living together with that species. Confirmation of identification requires dissection of the male reproductive tract (cf. Figs 37 & 38).

Distribution: Indigenous to the Iberian Peninsula, but has spread to many other parts of the world including North and South America, and Australia; introduced to South Africa prior to 1961 and subsequently recorded from the Eastern and Western Cape, KwaZulu-Natal and the Kruger National Park (Altena 1966). The only material available from KwaZulu-Natal was collected in gardens in Pietermaritzburg, but the

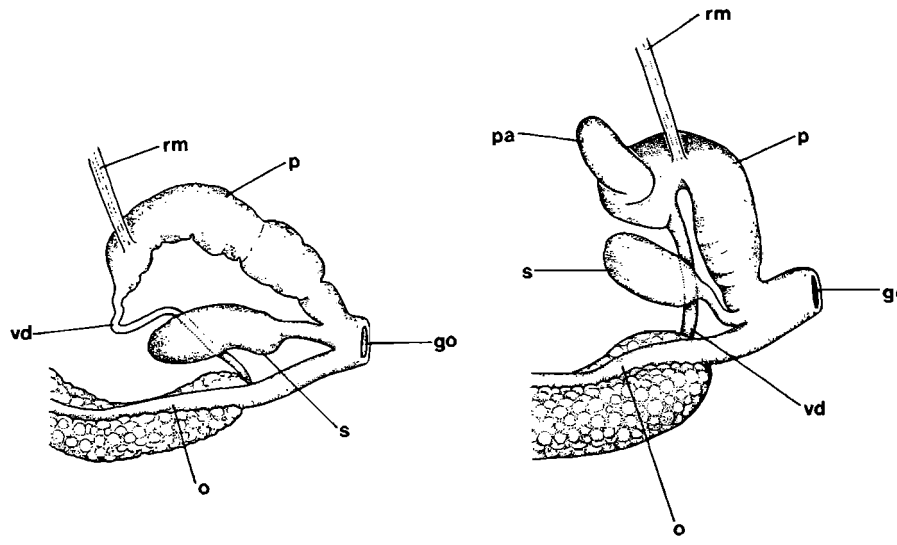


Fig. 37–38. *Lehmannia nyctelia* (Bourguignat, 1861) and *L. valentiana* (Férussac, 1821) – comparison of male genitalia. **37**. *L. nyctelia* – penis lacking an appendage (modified from Barker 1979). **38**. *L. valentiana* – penis with a distinct, blunt-ending appendage (redrawn from Waldén 1963). [go = genital opening; o = oviduct; pa = penial appendage; p = penis; rm = retractor muscle; s = spermatheca; vd = vas deferens].

species will almost certainly prove to occur in other urban areas.

Habitat: In gardens; in compost heaps and under logs, stones, flower pots and other objects lying on the ground, particularly in shaded areas.

Locality data – KwaZulu-Natal: Pietermaritzburg, suburban gardens.

Additional South African localities: Cape Town, Stellenbosch, George, Port Elizabeth, East London and the Kruger National Park.

Remarks: Known to be a pest of ornamental plants and crops in green houses.

Family Agriolimacidae

As for Limacidae but smaller (generally <40 mm in length); central point of mantle finger-print situated to right of mid-line, just above pneumostome; tail steeply sloping; intestine with three loops; herbivorous and frequently pests on crops.

All agriolimacid slugs occurring in South Africa are exotic, introduced from Europe amongst imported vegetation. All belong to the genus *Deroceras*.

Genus *Deroceras* Rafinesque, 1820

Fig. 39; Map 13

Type species: *Limax gracilis* Rafinesque, 1820 (= *Limax laevis* Müller, 1774).

Distribution: Essentially Palaearctic, but introduced to many temperate regions beyond this.

Fig. 39. *Deroceras* species; Botha's Hill, near Durban.

Note: The much used name *Agriolimax* Mörch, 1865, is a junior synonym of *Deroceras* (Waldén 1976).

Two species of *Deroceras* have been recorded in KwaZulu-Natal, *D. reticulatum* (Müller, 1774) and *D. laeve* (Müller, 1774), the latter more frequently. In both species the posterior keel is usually weak, the tail somewhat abruptly truncated and the pattern of concentric ridges on the mantle is centred to right of mid-line. Although there are differences in size and coloration (*D. reticulatum* – buff to brown or grey, often with darker flecks, mucus milky when irritated, extended length 35–40 mm; *D. laeve* – chestnut to dark brown, also often with dark flecks, mucus clear, extended length 15–25 mm), accurate species discrimination is not easy and requires dissection of the reproductive tract (*D. reticulatum* – penis short and broad, penial appendage complex; *D. laeve* – penis long and sinuous, penial appendage simple, *fide* Kerney & Cameron 1979). However, since very few KwaZulu-Natal specimens have been dissected, it is not possible to discuss the two species separately. Both are thought to be have been introduced to southern Africa from the northern hemisphere prior to 1898 and are now widely distributed in the region.

Distribution (Map 13): Unlike species of *Limax* and *Lehmannia*, which have not spread far beyond human settlement, *Deroceras* species have invaded rural areas extensively, including more or less pristine indigenous habitats. They probably occur throughout KwaZulu-Natal.

Habitat: *Deroceras* specimens from KwaZulu-Natal have been found in a wide range of habitats from gardens and agricultural land to montane *Podocarpus* forest and even relatively dry *Spirostachys* woodland. Under stones and logs, in leaf-litter, on tree trunks and on crop plants (lettuce, cabbage etc). In Europe, *D. laeve* is evidently restricted to somewhat moister habitats than *D. reticulatum*.

Recorded localities (Connolly 1939, Bruggen 1964, Altena 1966):

Deroceras reticulatum (Müller, 1774)

KwaZulu-Natal: Pietermaritzburg; Albert Falls; Harding, under logs in grassland.

Additional South African localities: Cape Town, Ceres, Stellenbosch, Caledon, Knysna and East London.

Deroceras 'laeve' (Müller, 1774) [see remarks]

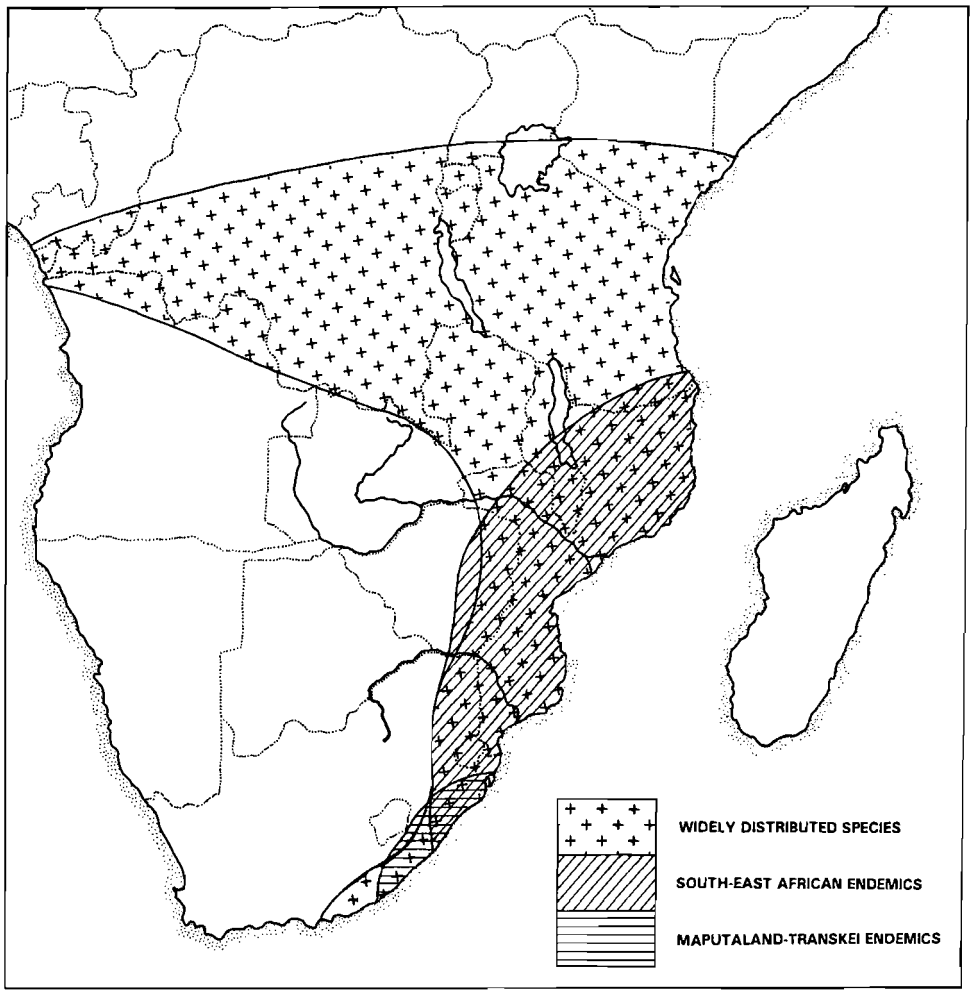
KwaZulu-Natal: Royal Natal National Park; Cathedral Peak; Underberg; Harding; Boston; Howick; Thornville; Pietermaritzburg; Albert Falls; Durban; Scottburgh; Umhlali Beach, coastal bush; Kokstad.

Additional southern African localities: Cape Town, Jonkershoek, Knysna, Queenstown, Kruger National Park, Swaziland and Namibia.

Additional locality data (*Deroceras* sp.): KwaZulu-Natal: Itala Game Reserve, under stones in riverine woodland; Ngome Forest, mist-belt *Podocarpus* forest, on tree trunk; Hluhluwe Game Reserve, *Spirostachys* woodland, in leaf-litter and on vegetation beside Hluhluwe Dam at Maphumulo; Pongola Bush Nature Reserve, montane *Podocarpus* forest, on tree trunks and under stones; Incandu Forest Reserve, under stones in grassland near hiking hut and in nearby vlei; Drakensberg Gardens, Underberg; Blinkwater, under bark of fallen log in *Eucalyptus* plantation; Bisley Common, Pietermaritzburg; Wartburg, in lettuce; Botha's Hill, in garden; Krantzkloof Nature Reserve, on tree trunk; Kloof, on tree trunk in garden.

Remarks: A third, similar species, *D. panormitanum* (Lesson & Pollonera, 1882) [synonym *D. caruanae* (Pollonera, 1891) *fide* Giusti 1986, but see also Van Goethem & De Wilde 1985], has been recorded (as *D. caruanae*) in the Western Cape and may well also occur in KwaZulu-Natal. Indeed, in both Australia and New Zealand, the earlier records of *D. laeve* are now thought to have been based on misidentified specimens of *D. panormitanum* (cf. Altena & Smith 1975, Barker 1979). This raises doubts regarding the validity of early records of *D. laeve* in South Africa, although the more recent record of the species from emergent vegetation beside a stream near Nelspruit (Mpumalanga) (Appleton 1974) conforms to the habitat preferences shown by the species in Europe. Els (1978) has also reported the species from the Northern Transvaal. Smith's record of the species from South Africa (Smith 1989) was based on material from the Comoro Islands (Backeljau, *pers. comm.*). Since *Deroceras* species are potentially significant pest species, a detailed study of their distribution and abundance is urgently needed. Modern techniques of allozyme electrophoresis and DNA sequencing could prove to be of value in confirming the identity of material.

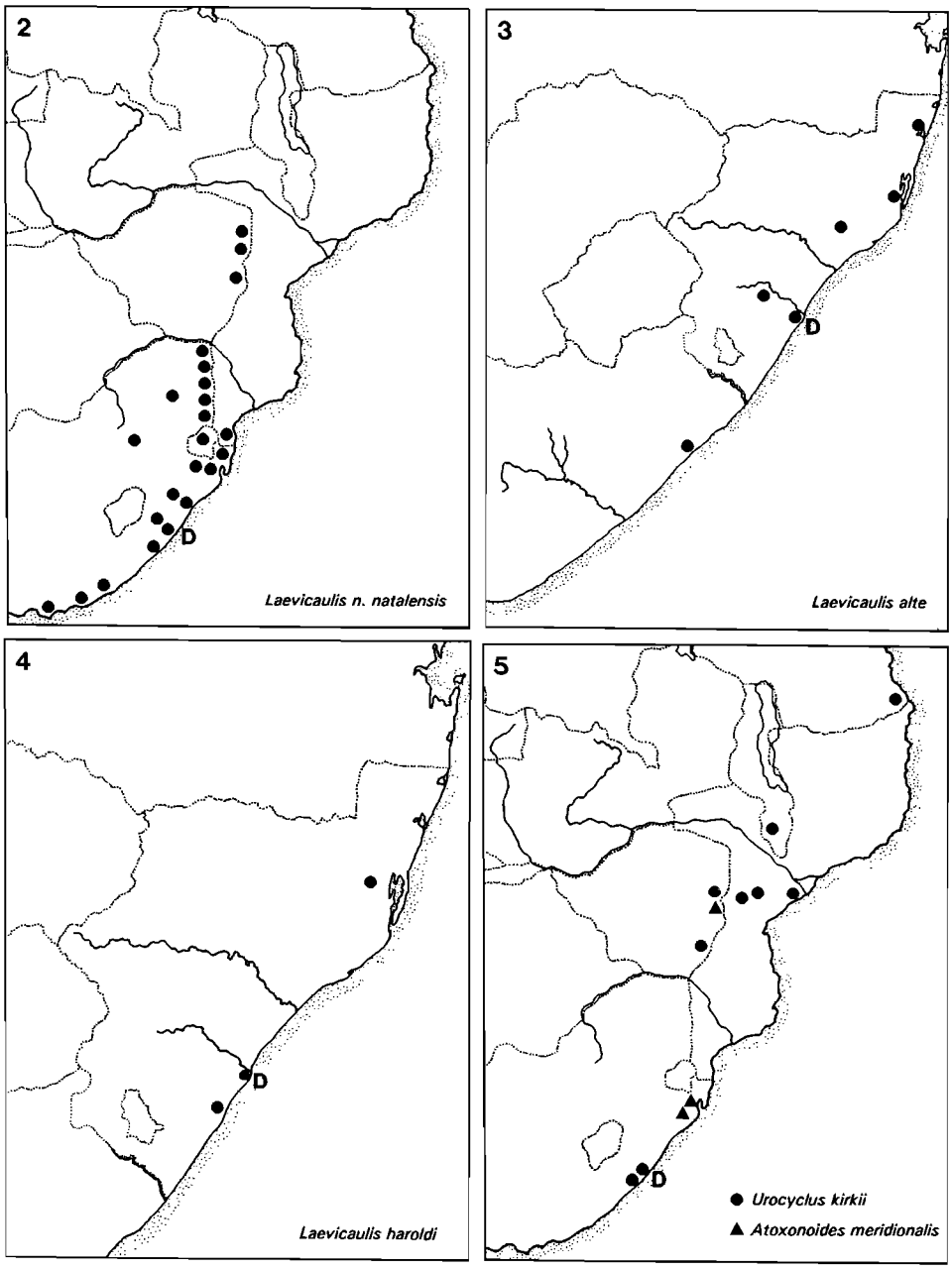
The common occurrence of *Deroceras* species on market garden vegetables such as lettuce and cabbage, may well account for their extensive penetration into rural and pristine habitats. The discarded outer leaves of such plants taken into conservation areas by reserve staff and visitors could easily result in the slugs spreading into the wild from dustbins and refuse middens. Bruggen's puzzlement as to '...why other tourist attractions, such as the game reserves in Zululand, are still free from imported pulmonates' (Bruggen 1964: 166) need no longer cause confusion – *Deroceras* species are now present in the Hluhluwe-Umfolozi Complex. That this has seemingly taken a long time may reflect the fact that the land has never been cultivated to an appreciable degree and that the reserves have been proclaimed for more than 100 years, for most of which time access has been severely restricted.



Map 1. Map of sub-Saharan Africa showing distribution of slug fauna with respect to biogeographical groupings.

BIOGEOGRAPHY

Although the various slug families are not closely related and do not constitute a single phylogenetic entity, analysis of the distributions of KwaZulu-Natal's indigenous slugs reveals interesting patterns. Whilst acknowledging that the distribution limits of the species are not well established, the slug fauna of KwaZulu-Natal may be conveniently divided into three biogeographical components (Table 1, Map 1). Firstly, Maputaland/Transkei (transitional) endemics (including all four species of *Chlamydephorus* and *Laevicaulis haroldi*), secondly, south-east African endemics (all the urocyclids: *Atoxonoides meridionalis*, *Elisolimax flavescens* and *Urocyclus kirkii*) and thirdly, species whose distributions continue northwards into central and East Africa (the veronicellids *Laevicaulis natalensis* and *L. alte*). The last



Maps 2–5. Distributions of slug species. **2.** *Laevicaulis natalensis natalensis* (Krauss, 1848). **3.** *Laevicaulis alte* (Férussac, 1821) in KwaZulu-Natal. **4.** *Laevicaulis haroldi* Dundee, 1980. **5.** *Urocyclus kirkii* Gray, 1864 [●] and *Atoxonoides meridionalis* (Forcart, 1967) [▲].

two groups are essentially comprised of species of subtropical or tropical affinity, reaching their southerly limits of distribution in eastern South Africa. Although the correlation between the families and distribution pattern is striking and worthy of

further analysis, the most obvious feature of the slug fauna of KwaZulu-Natal is the complete absence of species-level taxa showing affinities with the Cape fauna (Table 1). The ranges of those species which do extend into the Eastern Cape (e.g. *Laevicaulis natalensis* and *Chlamydephorus sexangulus*), do so only marginally and they are clearly transitional or subtropical/tropical elements. Furthermore, the characteristic slug taxa of the Cape, e.g. species of *Oopelta*, *Ariopelta* and *Ariostralis*, are unknown in KwaZulu-Natal. Griswold (1991), using cladistical methodology, concluded similarly that the south-east African afromontane spider fauna shows affinities with tropical Africa rather than with the Cape. Likewise, Poynton (1988) noted that not one species of southern African amphibian is shared by both the tropical East African fauna and the Cape fauna (see also Werger (1978) for examples in other animal groups).

Only at generic level are taxa shared between the Cape and KwaZulu-Natal slug faunas and then only in the case of the genus *Chlamydephorus* (cf. *C. purcelli* Collinge, 1901, a possible Table Mountain endemic). Records of the urocycline slugs *Dendrolimax osborni* Pilsbry, 1919 and *'Urocyclus' kraussianus* (Heynemann, 1862) from the southern and western Cape respectively, are suspect (Van Goethem 1977 and p. 217 herein) and cannot be taken to indicate the presence of a urocycline element in the Cape slug fauna. Thus even at family level, only the Chlamydephoridae has indigenous representatives in both the Cape and KwaZulu-Natal.

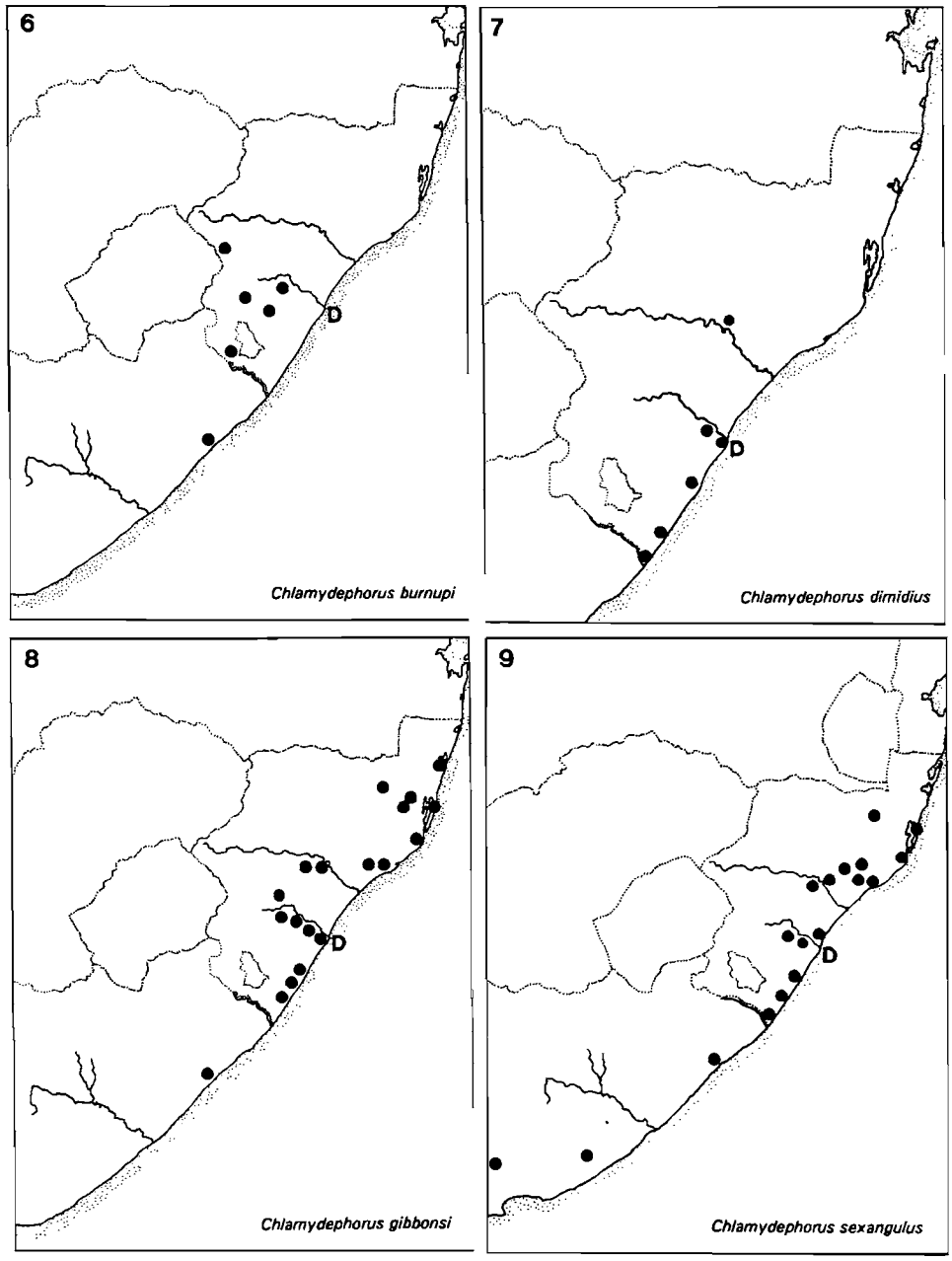
In the context of the relative isolation of the Cape slug fauna, it is interesting to note that *Oopelta*, *Ariopelta* and *Ariostralis* – confined to the winter-rainfall Mediterranean regions of the Cape – are the only indigenous representatives of the largely holarctic family Arionidae occurring in sub-Saharan Africa (see Bruggen 1969 and Sirgel 1986). That the Chlamydephoridae has representatives in both the Cape and KwaZulu-Natal (and further north in Mpumalanga, the Kruger National Park and the eastern highlands of Zimbabwe) strongly suggests that it is part of the southern relict fauna, and was thus presumably more continuously distributed in South Africa during a wetter climatic period when suitable habitats were more widespread (Axelrod & Raven 1978), *C. purcelli* being a relict species on Table Mountain, isolated there when the climate became drier.

TABLE 1

Summary of KwaZulu-Natal slug biogeographical data.

Faunal category	Number of species	Percentage of indigenous slug fauna
Cape elements	0	0
Maputaland-Transkei (transitional) endemics	5	50
South-east African endemics	3	30
Species widely distributed in south, central and eastern Africa	2	20

Bruggen (1978) discussed the biogeography of slugs in South Africa and analysed this in relation to climatic variables, particularly rainfall and temperature. Not unexpectedly, slug distributions correlate closely with these variables. Summarising



Maps 6–9. Distribution of *Chlamydephorus* species occurring in KwaZulu-Natal. **6**. *C. burnupi* (Smith, 1892). **7**. *C. dimidius* (Watson, 1915). **8**. *C. gibbonsi* (Binney, 1879). **9**. *C. sexangulus* (Watson, 1915).

Bruggen's comments, it is possible to divide South Africa into three regions with respect to its indigenous slug fauna:

- an arid central and western area with no slugs.
- a relatively cool, winter-rainfall, Mediterranean region (Cape) with only endemic species.
- a warmer, summer-rainfall region with both transitional endemics and more widespread tropical species.

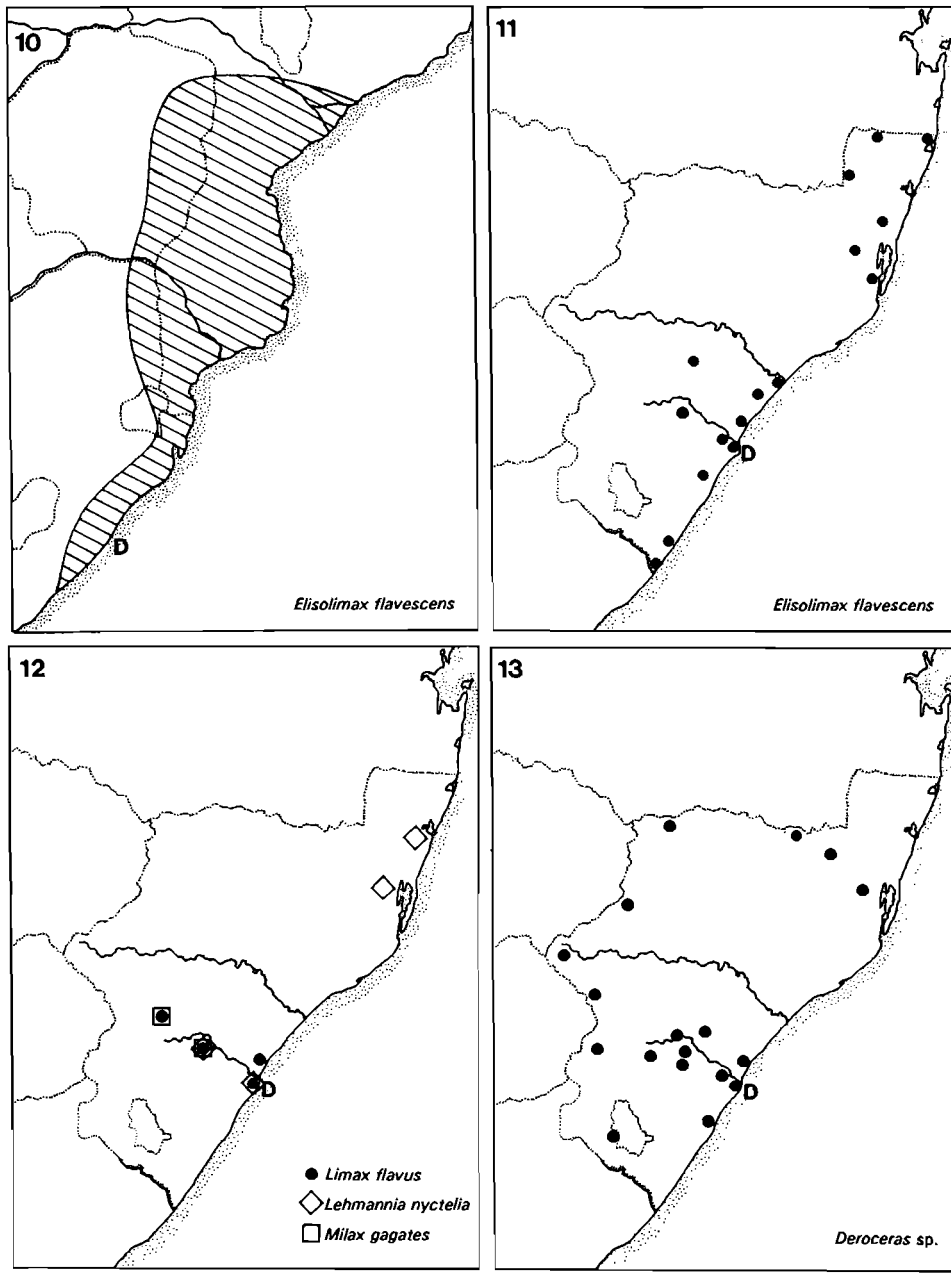
SLUG CONSERVATION IN KWAZULU-NATAL

Issues pertinent to the conservation of slugs in KwaZulu-Natal concern only the indigenous species. Although the introduced species may potentially compete with and displace them, there is currently no evidence of this. Of the indigenous slugs, *Laevicaulis natalensis natalensis* and *Elisolimax flavescens* are common in natural habitats and have also adapted well to urban conditions, such that they are familiar inhabitants of gardens in moister areas. The distribution and abundance of *Laevicaulis alte* within the province is uncertain. It is, however, known to be widely distributed to the north and in other continents, and is thus not a conservation concern; it is regarded as a serious agricultural pest in India (Raut & Mandal 1986). *Urocyclus kirkii* has a relatively wide distribution (KwaZulu-Natal south coast to southern Tanzania) and is probably more common than available records suggest (occurring also in gardens).

Of greater conservation concern are *Atoxonoides meridionalis* and *Laevicaulis haroldi*, which seem to be both rare and of limited distribution. *A. meridionalis*, a south-east African endemic, is evidently restricted to relatively unspoilt indigenous habitats. Most records within KwaZulu-Natal are from conserved areas in the moister coastal belt. *Laevicaulis haroldi*, one of two slug species endemic to KwaZulu-Natal, is known only from three localities at or near the coast, one of which has been destroyed to make way for a road. It must thus rank as one of the province's most threatened slugs.

Undoubtedly the most important group, however, in terms of conservation, are the carnivorous Chlamydephoridae. This is one of five terrestrial molluscan families belonging to the southern relict fauna and is southern Africa's only endemic terrestrial molluscan family (if dorcasids are referred to the Acavidae cf. Bruggen 1969). Twelve species were recognised by Forcart (1967), but their distributions are still only poorly known. I here recognise four species from KwaZulu-Natal, one of which – *Chlamydephorus dimidius* – is known only from this province. Judging from available evidence, chlamydephorids are primarily inhabitants of relatively undisturbed natural habitats, particularly moist indigenous forests, and are rarely abundant. Such habitats have been severely reduced in extent within KwaZulu-Natal during the last century and are now much fragmented. The distributions of their slug inhabitants are thus likely to be similarly restricted and discontinuous. The specialised feeding habits of chlamydephorids and their position at a higher trophic level than other slugs may render them still further susceptible to extinction (Lawton 1995).

It is impractical to consider measures specifically aimed at the conservation of any of the province's rare or endemic slugs. These species are, however, a characteristic



Maps 10–13. Distributions of slug species. **10**. Total known distribution of *Elisolimax flavescens* (Keferstein, 1866). **11**. *E. flavescens* in KwaZulu-Natal. **12**. *Limax flavus* Linnaeus, 1758. [●], *Lehmannia nyctelia* (Bourguignat, 1861) [◇] and *Milax gagates* (Draparnaud, 1801) [□] in KwaZulu-Natal. **13**. Distribution of *Deroceras* species in KwaZulu-Natal.

and unique element of regional biotic diversity and thus of some conservation importance. Habitat transformation and fragmentation are probably the most

significant factors likely to influence the continued survival of these slug species. Their conservation would thus be best addressed by measures limiting the degradation, reduction and fragmentation of the habitats in which they occur. The effect of habitat fragmentation on organisms with such limited powers of dispersal is likely to be considerable in the long term. As a result of their very limited vagility, the large areas of transformed land separating populations of anthropophobic slugs living in more or less pristine habitats effectively represent impenetrable barriers (already such populations are genetically isolated). In addition, large natural areas in southern Africa are likely to experience a change in biome type with continuing climatic change; for habitats at or near the margins of climatic zones these ecological changes are likely to be considerable and rapid – perhaps too large and too rapid for the existing flora and fauna to survive. Any significant change in the floral composition of a habitat is likely to have a dramatic effect on its slug fauna and indeed its mollusc fauna in general.

Accepting these underlying threats, it must be said that our knowledge of the habitat requirements of most of the province's indigenous slug species and the extent to which they are habitat specific, is extremely limited and in need of further study. The different vegetation types have not been sampled to the same degree and there is perhaps a bias suggesting greater specificity for indigenous forests than might be the case. This may, to some extent, simply reflect the fact that molluscs are more abundant in these forests which, because the catch per unit effort is higher, are sites favoured by collectors.

The species *Laevicaulis haroldi*, *Chlamydephorus burnupi* and *C. dimidius* almost certainly meet the IUCN Species Survival Commission criteria (IUCN 1994) for inclusion in the 'Red List' and applications to this effect are being drawn up.

ECONOMIC IMPORTANCE OF SLUGS IN KWAZULU-NATAL

Slugs are well known agricultural and horticultural pests (Hunter & Runham 1971, South 1992), but little research has been done to quantify the impact of the damage they cause. Indeed, the inferred status of many species as economically important pests remains to be confirmed. Almost nothing is known regarding the occurrence and scale of slug damage to crops in KwaZulu-Natal. Of the indigenous species, it would appear that only *Laevicaulis natalensis natalensis* (perhaps also *L. alte*) and *Elisolimax flavescens* occur in numbers sufficient to cause significant damage. *L. natalensis natalensis* is common in suburban gardens and is probably considered a pest by many gardeners, but it does not seem to have been recognised as a serious agricultural pest. *E. flavescens* is similarly common in gardens and it is undoubtedly regarded as a nuisance by gardeners. However, it has also been reported to cause significant damage to banana crops by rasping the skin of the ripening fruit, which results in disfiguring, cork-like marks (Jones 1981). There are also reports of this slug damaging citrus crops in Swaziland (Bedford 1978).

Of greater economic concern in KwaZulu-Natal are the introduced slugs, particularly those of the families Limacidae and Agriolimacidae. At present members of the other two introduced families, Arionidae and Milacidae, remain rare and are known from very few localities. Species of *Lehmannia* (Limacidae) and *Deroceras*

(Agriolimacidae), however, are more widespread and sometimes abundant. They are well-known pests of leaf, fruit and root crops, and of newly planted seeds in many parts of the world, including regions to which they are indigenous (South 1992). There is no doubt that they represent a potential threat to crops in South Africa, particularly species of *Deroceras*, but reports of serious damage have not, as yet, emerged in KwaZulu-Natal. *Deroceras reticulatum* is frequently cited as being the most abundant and widespread of introduced slugs in countries to which it is not native (Barker 1982).

CONCLUDING REMARKS

Of the twelve terrestrial slug taxa (i.e. not including *Onchidium*) recorded from KwaZulu-Natal by Collinge (1910), nine are recognised herein as valid species occurring in the province (not necessarily under the same name – see Table 2). Thus, in the intervening 87 years since Collinge's paper, an additional nine slug taxa have been documented from the province – a doubling of the fauna. Of these subsequently recorded species, three represent new species (*Laevicaulis haroldi*, *Chlamydephorus dimidius* and *Atoxonoides meridionalis*, the first two being provincial endemics), two are range extensions for indigenous taxa (*Laevicaulis alte* and *Urocyclus kirkii*), and four are newly recorded introductions (*Lehmannia nyctelia*, *L. valentiana*, *Limax maximus* and *Deroceras laeve*). The list of species will doubtless grow as more remote parts of the province and the most poorly collected habitats become more thoroughly sampled, and as the ranges of introduced taxa spread.

TABLE 2

KwaZulu-Natal slug taxa listed by Collinge (1910), with their currently used names (* = taxa discussed by Collinge, but of which he had no material from KwaZulu-Natal).

Name used by Collinge	**Current name**
Limax flavus Linn.	*Limax flavus*
Milax gagates (Drap.)	*Milax gagates*
Agriolimax agrestis (Linn.)	*Deroceras* sp., *?reticulatum*
Urocyclus kirkii Gray*	*Urocyclus kirkii*
Urocyclus flavescens (Keferst.)	*Elisolimax flavescens*
Urocyclus fasciatus v. Martens	*Elisolimax flavescens*
Urocyclus pallescens Ckll.	*Elisolimax flavescens*
Urocyclus kraussianus (Heyn.)*	*nomen dubium*
Apera gibbonsi (W. G. Binn.)	*Chlamydephorus gibbonsi*
Apera burnupi E. A. Sm. [*non* Smith]	*Chlamydephorus sexangulus*
Apera natalensis Cllge	*Chlamydephorus burnupi*
Arion fuscus (Müll.)	*Arion intermedius*
Veronicella natalensis (v. Rapp.)	*Laevicaulis natalensis natalensis*
Veronicella saxicola Ckll.	*Laevicaulis natalensis natalensis*

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